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Annual Report 1955

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

E. L. Demmon,
Director

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

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SOUTHEASTERN FOREST EXPERIMENT STATION

December 31, 1955

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CONTENTS

Annual Report, 1955
Southeastern Forest Experiment Station

INTRODUCTION

This year's Annual Report gives the highlights of forest research in progress and attempts to set studies within their proper framework of need and usefulness as related to forest conditions. Southern forestry has become such a large-scale business that it has often been impossible to know just what the conditions actually were. With the completion of the Timber Resource Review in 1955, however, up-to-date forest resource facts became available on a uniform basis for all five states in the Station's territory. Thus, for the first time since the Reappraisal of 1945, statistics are at hand to show the character of the forest resource for the whole Southeast and the trends operating in our forests. In presenting forest statistics for the Southeast in this report, we cover only this Station's territory, which includes Virginia, the Carolinas, Georgia, and Florida.

Sixty-four percent of the land area of the Southeast is in forest. Commercial forest, excluding unproductive and reserved land, amounts to 91.6 million acres, an increase of 6.0 million acres, or $6\frac{1}{2}$ percent, since 1945. Most of this is accounted for by abandonment of farm land. Nine percent of the commercial forest land is in public ownership, with the national forests covering 4.5 million acres, or about 5 percent. Wood-using industries have been acquiring additional forest land in recent years and now own about 14 million acres in the Southeast. Other classes of private owners, excluding farmers, have about an equal amount. Farmers are by far the leading class of owner, with nearly 55 million acres, or 60 percent of all the commercial forest. Because farm owners predominate, over one-fourth of the forest land is in ownerships of less than 100 acres each. Farmers number 710,000 and make up 80 percent of all private owners.

The trend in timber supply is toward more hardwood and less pine. Since 1945, hardwood sawtimber has increased 9 percent in volume, while softwood sawtimber has decreased nearly 4 percent. The scarcity and cost

of quality lumber in local yards has brought the softwood decline home to many citizens. Softwood now makes up only 55 percent of the total sawtimber volume compared to 58 percent in 1945. The volume of all hardwood growing stock (trees 5 inches d.b.h. and over) has increased nearly 14 percent, but softwood has remained about the same. Utilization of cull hardwood trees has not kept pace with the annual volume increase, and the southeastern forests now contain nearly 150 million cords of low-quality hardwood.

Net annual growth is greater than at the time of the 1945 Reappraisal; 10 percent more in the case of softwood sawtimber, and 20 percent more in the case of hardwood. In 1952, softwood sawtimber growth exceeded cut by 17 percent, whereas hardwood growth exceeded cut by 51 percent. Growth of softwood growing stock exceeded cut by 12 percent; hardwood by 77 percent. This favorable growth-cut relationship for growing stock is particularly significant in the face of a timber cut 6 percent greater in 1952 than in 1944.

Forest productivity is reduced by a number of destructive agents, principally fire, insects, and disease. Total mortality in 1952 was 626 million board-feet, or about 5 percent of net sawtimber growth. Great progress has been made in fire prevention and control, but fire is still an ever-present menace. This was amply demonstrated in the spring of 1955 when a single fire burned over 175,000 acres. Eighty-six percent of the forest land is protected from fire but there are still over 13 million acres unprotected. Over half of this acreage is in Florida. Also, much improvement needs to be made in the control of insects and disease in the Southeast.

Forest productivity is also at a relatively low level because much of the forest land is understocked with trees. In addition to the 12 million acres of commercial forest land with less than 10 percent stocking, there are 15 million acres which are only 10 to 40 percent stocked. Planting offers an effective way to restore nonstocked land to productivity and it is estimated that the five southeastern states have 10.7 million acres of plantable area. The area of acceptable plantations to 1952 totaled only 872,000 acres; thus, an immense planting job lies ahead.

In recent years from 4 to 7 percent of the commercial forest land in the Southeast has been cut over annually. Subsequent growth is strongly influenced by the condition in which the forest is left after cutting. On recently cut lands in the Carolinas and Virginia, productivity rates high on 64 percent of the area, medium on 26 percent, and low on 10 percent. Deficient stocking, both existing and prospective, keeps many recently cut lands from qualifying for the high productivity class.

These Timber Resource Review facts re-emphasize major forest research needs in the Southeast. With farmers owning 60 percent of all the commercial forest land, timber management research must take into account

the problems of the small owner. Research is needed to develop ways to halt the conversion of pine stands to hardwood, including better ways of obtaining natural regeneration of pine and more economical methods of eliminating unwanted hardwoods. Profitable industrial uses must be developed for the huge volume of low-quality hardwoods to make room for pine and good-quality hardwoods. The current large-scale planting program and the backlog of nearly 11 million plantable acres emphasizes the need for rapid progress in genetics research to develop improved trees.

Mortality and growth losses due to destructive agents must be reduced. Improved control of disease in forest tree nurseries will help insure greater numbers of seedlings for the planting program. Research on the control of oak wilt should be intensified in order to prevent expansion of this disease, and continuing effort is needed to find ways to reduce littleleaf losses in shortleaf pine. More needs to be known about the causes of "blow-up" fires that do so much damage; reliable methods for predicting their occurrence have yet to be found. Better information is needed on the life history and habits of destructive insects, and more effective control procedures must be devised, especially through biological and forest-management methods.

E. L. Demmon

Director

FOREST MANAGEMENT

The Timber Resource Review shows several important trends in the forests and forestry practices of the southeastern states which will have a bearing on management decisions in the future. These trends include the increase in total commercial forest land area, an increase in hardwood sawtimber and a decrease in softwood sawtimber, annual net growth of all species in excess of the cut, and an increasing need for planting and other types of regeneration.

In meeting the challenge of these trends, management research has made considerable progress during 1955. First of all we are finding out more and more about sites and soils, and about the relative growth rates of different species on the same land. Considerable progress has been made in relating yield of both wood and gum resin to site, species, density, and other factors. Selection and breeding programs have made substantial progress toward improving both the quality and quantity of wood and gum yields. Planting and plantation management research in both pines and hardwoods have been increased. Natural regeneration techniques have been further refined, especially for loblolly pine. Naval stores research has resulted in newer and better tools for turpentining. Progress has been made in techniques for detecting and gauging high gum-yielding progeny in the breeding and selection of naval stores species. Stand improvement studies have been continued in an attempt to improve existing stands by pruning, thinning, cutting, girdling, and poisoning.

Artificial Regeneration

As pointed out in the Timber Resource Review, speeding up the reforestation of the 50 million acres of idle or near-idle forest land in this country is a clear challenge to the nation. Over 20 percent of all this plantable land is in the five southeastern states, where conditions are unexcelled for obtaining an early profit on a relatively low investment in forest planting. For these reasons, research on seed, nursery production, site preparation, plantation establishment, and plantation management is receiving increasing emphasis in the Station's research program.

Seed Laboratory Begins Research

The seed laboratory at the Georgia Forestry Center near Macon is now conducting part-time research on tree seed. This research is a cooperative arrangement with the Southeastern Station, Georgia Forest Research Council, Georgia Forestry Commission, and Region 8 of the U.S. Forest Service.

During the initial phases of seed extraction at the Georgia Forestry Commission extractory at Macon, Ga., severe seed coat scarification was observed after passage of the slash pine seed through the dewinger. This resulted in a loss of 8 percent in germination. The recommendations for elimination of this cause of injury have been successfully followed out.

Soil Texture is Important in Nurseries

In planting longleaf pine it is important that the most fibrous portion of the root system be developed at a depth where maximum soil moisture will be available; this is probably the bottom half of the planting hole. With this in mind, a cooperative study with the West Virginia Pulp and Paper Company was started in South Carolina. Longleaf pine seedlings of 1-0 stock were planted in each of several 10-inch soil profiles varying in texture from sand to sandy clay. One-year planting results show that it is possible to regulate both the number and position of lateral roots by manipulating soil profiles (fig. 1). For example, a nearly pure sandy profile gave an average of 13.6 lateral roots at a 7-inch depth as compared with a sandy clay soil profile which gave only 3.6 lateral roots at a 7-inch depth. Other profiles gave results intermediate between these two extremes.

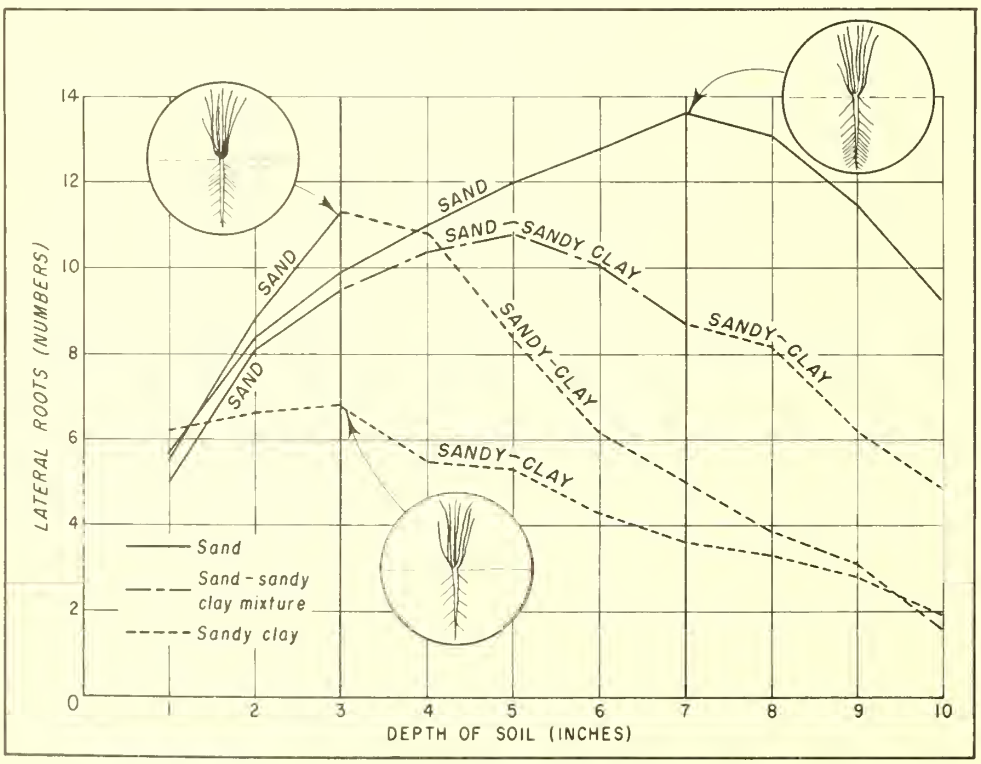


Figure 1.--Frequency of lateral roots of 1-0 longleaf pines at different depths when grown in artificial soil profiles, South Carolina.

Root-Pruning Increases Survival of Slash Pine

A repeat study of root-pruning in south Florida, similar to one in 1954, showed a consistent increase in survival for slash pine (table 1). The greater the time between pruning and lifting, the better the survival of the planting stock. The reason seems to be that the new root-growing points which form following root pruning start growth immediately when planted in the field.

Table 1.--Survival of planted South Florida slash pine by month of planting and root-pruning treatment

Time roots pruned before lifting (weeks)	Survival by month of planting			Average survival
	December	January	February	
	Percent			
6	74	76	81	77
4	70	61	63	65
2	69	55	66	63
Control	69	56	45	57
Average	70	62	64	65

Nursery Fertilizers Affect Planting Survival

Many tests have shown that similar-appearing seedlings from different nurseries may have distinctly different survival rates. In south Florida a fertilization study in one nursery revealed that the type of fertilizer, rate of application, and time of application are important in attaining high first-year survival of planted South Florida slash pine seedlings (table 2). It is concluded that the different survival rates of planted stock from different nurseries are often attributable to nursery fertilizer practices.

Clipping Needles not Recommended for Slash Pine Planting Stock

One of the most critical planting areas in the Southeast is in south Florida. In an attempt to conserve water and thus increase planting survival, the needles of South Florida slash pine were clipped before planting. First-year survival records show that clipping is not superior to no clipping.

Table 2.--First-year survival of planted seedlings by nursery fertilization treatment, South Florida slash pine

Fertilizer analysis N	Fertilizer analysis P_2O_5	Fertilizer analysis K_2O	Rate of application per acre	Survival according to time of application[1/] April only	April & July	April, July & Sept.	Average
- - Percent - -			Pounds	- - - - - - - - - Percent - - - - - - - - -			
3.3	6.6	16.5	605	57	69	73	66.3
4.0	10.4	4.0	500	66	67	61	64.7
12.0	4.8	.0	667	50	49	81	60.0
2.2	14.1	2.2	891	45	41	71	52.3
.7	9.9	19.9	753	47	38	68	51.0
.0	19.2	.0	167	53	48	45	48.7
--	(2/)	--	--	29	50	52	43.7
Average				49.4	51.7	64.4	55.2

1/ The amount of fertilizer shown under rate of application was applied each time.

2/ Control; no treatment.

Site Preparation Improves Survival of Longleaf and Slash Pine

In the sandhills of South Carolina and Georgia there are 3 million acres of deep sandy soils in need of planting. Because these areas are now mainly dominated by scrub oaks that draw heavily on soil moisture, successful establishment of pine requires a reduction in the scrub oak competition. Figures 2 and 3 show two of the most promising methods of site preparation: (1) deep furrowing in lanes through the scrub oak, and (2) complete clearing by plowing and disking. Of four site preparation methods tested, in cooperation with the South Carolina State Commission of Forestry, furrowing to an 8-inch depth resulted in the highest first-year survival of longleaf pine (table 3); however, since the plowed and disked area was planted soon after the treatment, this study cannot be considered final until planting tests are tried on areas where more time has been allowed for stabilization of the soil.

Table 3.--First-year survival of longleaf pine by site treatments in the South Carolina sandhills

Site treatment	Survival
	Percent
Furrowed (8-inch depth)	71
No release (check)	57
Plowed and disked	48
Released (45 percent of stems cut and stumps poisoned)	45

Figure 2.--Deep furrowing scrub oak lanes in preparation for planting longleaf pine in the South Carolina sandhills.

Figure 3.--Complete clearing by plowing and disking scrub oak areas in preparation for planting longleaf pine in the South Carolina sandhills.

Many acres in the flatwoods of northeast Florida support sparse stands of slow-growing longleaf pine. When these unprofitable stands are cut, the problems arise as to which species to plant and how to prepare these poor sites for planting. To compare growth and survival, slash and longleaf pine were planted on areas clearcut and burned the previous year. The site preparation tests included plowed furrows, single disking, multiple disking, and no site preparation. All site preparation work was done in July 1954, except the plowing of furrows, which was done in January 1955, just prior to the whole planting job. Figures 4 and 5 illustrate two types of treated areas. One-year survival records (table 4) show that both species survived much better in plowed furrows than on the disked or control areas, and slash and longleaf had identical survival records in the planted furrows.

Table 4.--First-year survival of longleaf and slash pine by site treatments in northeastern Florida flatwoods

Site treatment	Survival	
	Slash	Longleaf
	Percent	
Plowed furrow	66	66
No preparation (check)	53	33
Multiple disk	46	31
Single disk	52	30
Average	54	40

Figure 4.--Furrows plowed on cutover flatwoods land in preparation for planting, north Florida.

Figure 5.--Cutover flatwoods land multiple-disked in preparation for planting, north Florida.

New Piedmont Hardwood Planting Projects

In line with the search for better hardwood planting stock, studies of yellow-poplar seedling grades have been installed at Athens, Georgia, and Statesville, North Carolina. The seedlings are being graded mainly by diameter of the root collar (also by root type at Statesville). Figure 6 shows yellow-poplar seedlings corresponding to the 5 grades used at Athens.

Figure 6.--Five seedling grades of yellow-poplar nursery stock being tested for survival and early growth at Athens, Georgia.

During 1955 several hardwood species have been given test plantings on lands of the University of Georgia at Athens, as follows: black locust, white ash, yellow-poplar, cottonwood, black walnut, white oak, chestnut oak, Chinese chestnut, northern red oak, scarlet oak, and sawtooth oak. In addition, sycamore cuttings were outplanted and showed a survival rate of 25 percent. Next year, plans are being made to plant cottonwood cuttings on a larger scale. Related work on hardwood seed production is now under way at Athens (fig. 7).

At Statesville, a planting test of species on three sites is being installed for white oak, yellow-poplar, and white ash. The planting areas are good, average, and poor old-field sites. Also at Statesville, an aboretum of hardwood species is being planned. The projects at Statesville are a result of a joint effort by the Furniture, Plywood, and Veneer Council of the North Carolina Forestry Association, the Duke Power Company, and the Station.

Figure 7.--A seed trap installation in a cove hardwood stand, Athens, Georgia. Yield, periodicity, and viability of cove hardwood seed are being studied.

Figure 8.--Seventeen-year-old yellow-poplar plantation on a good hardwood site (site index of 114 feet at 50 years) near Athens, Georgia. The plantation is now badly in need of thinning.

Yellow-Poplar Plantations Highly Successful in Georgia Piedmont

One of the most successful species for planting on good hardwood sites in the Georgia Piedmont is yellow-poplar. At the same time, good quality yellow-poplar logs are less plentiful than any other forest product in central Georgia. Thus, it becomes highly profitable to recognize these planting sites, plant yellow-poplar, and apply intensive management to existing plantations.

After 17 growing seasons, an old-field yellow-poplar plantation near Athens, Georgia, had a basal area of 153 square feet per acre and a volume of 30 cords per acre (fig. 8). The trees in this stand averaged 5.6 inches d.b.h. and 70 feet in height.

Natural Regeneration

In the Southeast, a major bottleneck in the big planting program ahead has been the lack of planting stock. Although tremendous strides have been made in expanding seed collections and nurseries, natural regeneration remains by far the most important method of reforestation. Accordingly, natural regeneration must assume a major role in the forestry picture for an indefinite period. Natural regeneration is particularly adapted to areas of mature pine or pine-hardwood stands about to be harvested, and where seed trees can be selected and released before the final harvest cut.

Loblolly Pine Seed Tree Requirements

In making harvest cuttings by the seed tree method, there is always the question of how many seed trees will be necessary for satisfactory restocking. Of course, the number of seed trees varies according to such factors as the size and fruitfulness of the seed tree, type of seed year, whether or not the tree has been released previously, whether or not there has been site preparation, and what degree of stocking is to be considered satisfactory.

During the past 10 years, comprehensive large-scale tests in the Bigwoods Experimental Forest in eastern North Carolina and special studies in southeastern Virginia have answered many of the questions about regeneration of loblolly pine by the seed-tree method (fig. 9). Table 5 shows the relative seed-tree requirements in a poor seed year for a 75-percent milacre stocking in the first year after logging as affected by selection of seed trees for past fruitfulness, release of seed trees, and site preparation.

Table 5.--Relative seed-tree requirements in a poor seed year for a 75-percent milacre stocking in the first year after logging, Franklin, Virginia

Fruitfulness of seed trees	Condition of seedbed: Logged	Logged and burned	Disked and logged
SEED TREES NOT RELEASED			
	Percent	Percent	Percent
Average	100	67	33
Most fruitful	67	45	22
SEED TREES RELEASED			
Average	12	8	4
Most fruitful	8	5	3

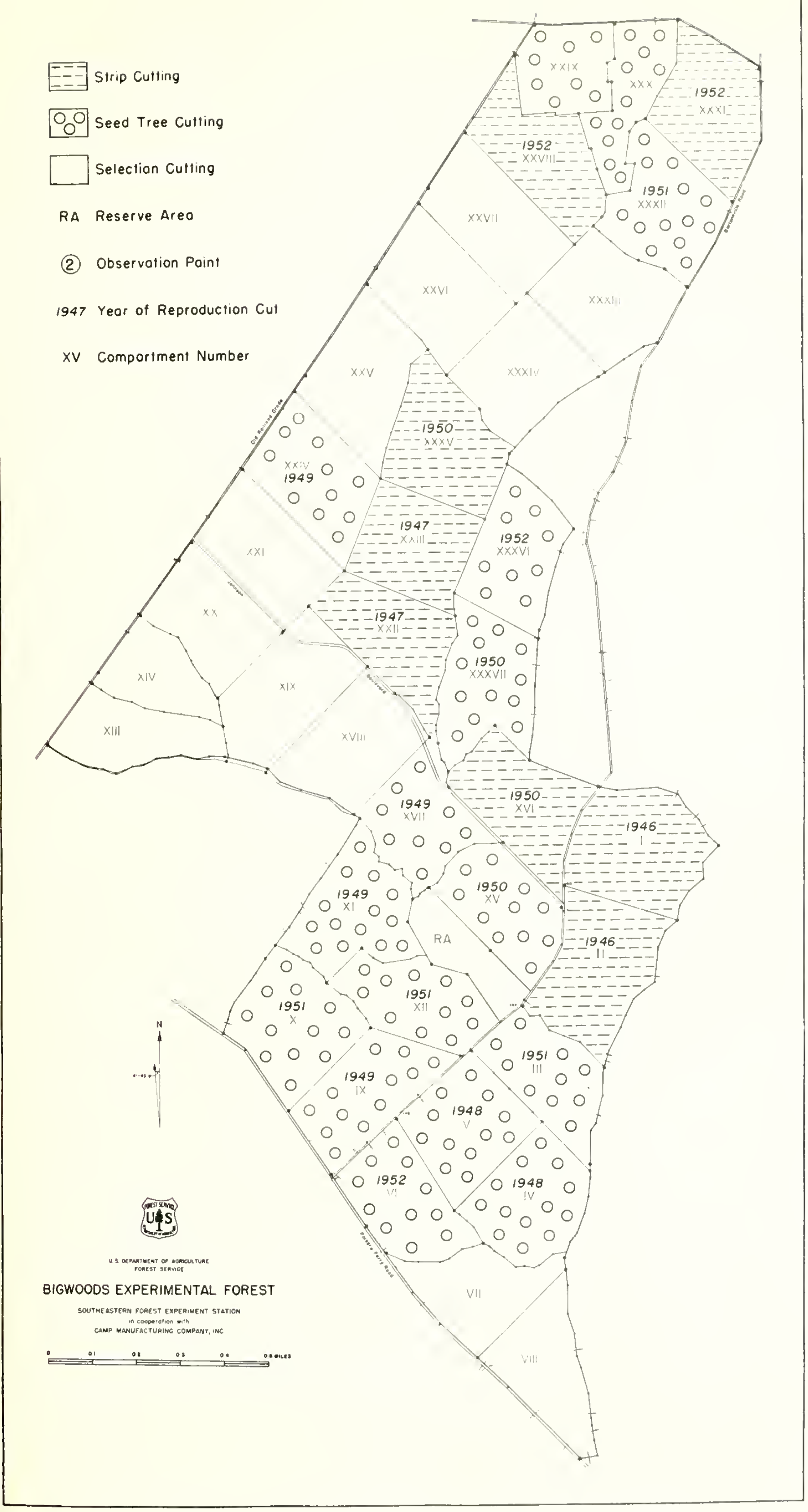


Figure 9.--Arrangement of compartments in large-scale test of management systems in loblolly pine on the Bigwoods Experimental Forest in eastern North Carolina

This table shows that releasing crowded seed trees 3 years before the harvest cut will increase seedfall enough so that only about one-eighth as many seed trees will be required; selecting seed trees on the basis of fruitfulness will increase seedfall enough so that only about two-thirds as many seed trees will be required; burning an area in late summer and within one year after logging will reduce the amount of seed or number of seed trees needed by one-third; and disking an area before logging will reduce seed-tree requirements by two-thirds. The total number of seedlings established was not increased greatly by site preparation; rather, the total number of seedlings was directly related to seed supply. However, the distribution of stocking or percent of stocking by milacres was much higher on areas where the site had been either burned, disked, or the hardwoods cut and poisoned.

Site preparation is not only effective in getting better distribution of the seedlings on an area, but it also leaves more seedlings to grow, free from hardwood competition (fig. 10). With no seedbed preparation or hardwood control other than that which resulted from tractor logging, 63 to 68 percent of the total stocking of seedlings was free of serious hardwood competition. When similar areas were burned after logging, free seedlings amounted to from 70 to 79 percent of the total stocking of seedlings free to grow. In this case the erratic results of fire, indicated by the greater range in the percentage of free seedlings, became evident with the elimination of the more or less constant cover of larger hardwoods. Where seedbed preparation consisted of disking before logging rather than burning after logging, and larger hardwoods were also poisoned, the free-to-grow percentage was 82 to 95 percent. The higher percentage of free pine seedlings in disked, compared with burned, compartments demonstrates the greater effectiveness of disking in controlling small hardwood stems.

A 10-year record of seed production at the Hitchiti Experimental Forest in the Georgia Piedmont shows that residual sawtimber-size trees left by shelterwood and seed-tree cuttings produced 3 to 6 times more sound loblolly and shortleaf pine seed per square foot of residual basal area (2 to 6 years after release) than did well-stocked stands. However, when

Figure 10.--Percent of total stocking free to grow in relation to cultural treatments and number of years since harvest cutting of loblolly pine, Bigwoods Experimental Forest, North Carolina. Based on twenty-two 35-acre compartments.

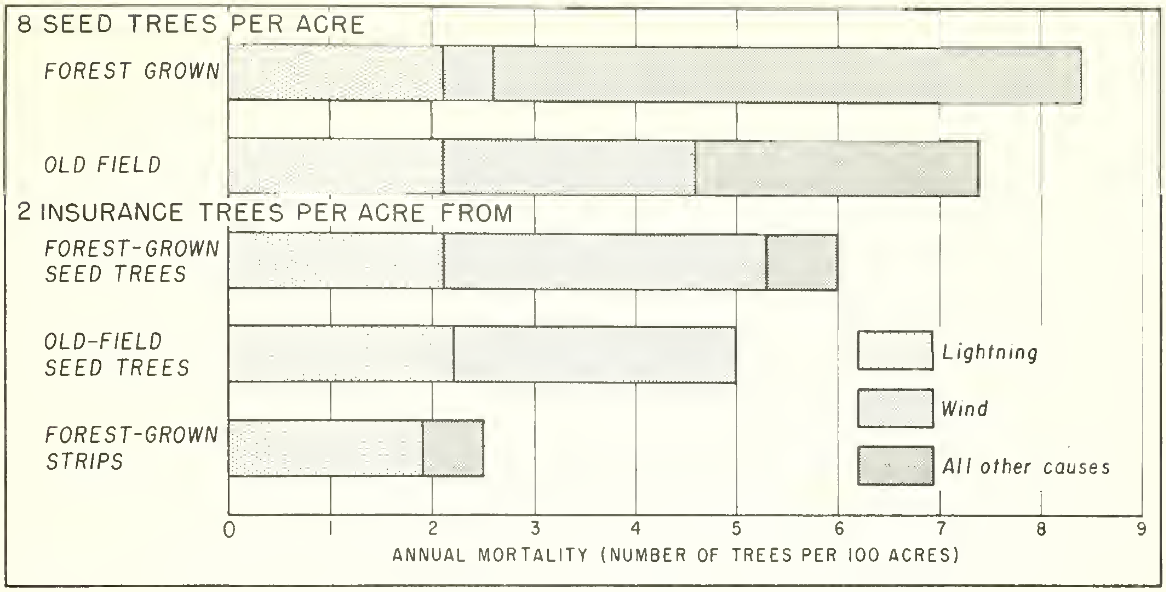


Figure 11.--Annual mortality of loblolly pine leave trees per 100 acres during regeneration and young stand development, Bigwoods Experimental Forest, North Carolina.

considered in terms of seed supply for regenerating a new stand, the unreleased stands also deposited enough seed to restock the forest during 3 years of the 10-year period. As a result of seed-tree release cuttings, enough seed was produced in two additional seasons to provide an adequate catch of seedlings, but only when combined with a good seedbed and favorable rainfall.

Loblolly Pine Seed-Tree Mortality

In planning for natural regeneration by the seed-tree method, it is often difficult to predict the rate and extent of seed-tree mortality for a given period of time. Eight-year records of twenty-two 35-acre compartments used in a test of management systems at the Bigwoods Experimental Forest show that the main causes of seed-tree mortality are lightning, wind (not including the 1954 hurricane), fire, logging damage, and insects. More seed trees die during the first few years following logging than in later years. Some of the early mortality can be associated with tree injury or change of environment due to logging. After two or three years the principal causes of mortality are lightning and wind. Figure 11 shows that lightning mortality averaged about 2 trees per 100 acres per year regardless of the number of seed trees left per acre or the origin of the stand. Wind assumes a greater role where fewer trees are left per acre and on old-field sites as compared with forest grown sites. Other causes of mortality vary according to logging technique, weather at time of logging, presence of insect infestations, and the severity of fire damage where fire is used in preparing the seedbed.

Less than 1 percent of the seed trees died per year for all seed-tree areas during the average regeneration period of 3.3 years. As a result of this study the insurance-tree plan of leaving two trees per acre for an extended period of time is not recommended. Two trees are usually inadequate to reseed an area following wildfire, and the smaller the number of trees left per acre, the greater is the percentage that succumb to wind and lightning.

Next to planting or site preparation for natural regeneration, stand improvement measures have probably been the most important factor in the recent trend to better forestry practices in both pine and hardwood forests of the Southeast. There have been increasing demands for economical ways to control undesirable trees and other vegetation, and, at the same time, to improve the quality and growth of the residual pine and hardwood stands.

Sweetgum Control with 2, 4, 5-T

In the South Carolina flatwoods, a common method of releasing loblolly pine from undesirable hardwood competition is by using 2, 4, 5-T in frills. Tests at the Santee Experimental Forest show that an effective and quick kill of sweetgum is possible by using 2, 4, 5-T in oil or in water plus a wetting agent. Figure 12 shows that the oil and 2, 4, 5-T mixture is superior to either water and 2, 4, 5-T or water and 2, 4, 5-T plus a wetting agent. However, the wetting agent does improve the results of a water mixture, especially during the May to July period. Treatments of oil and 2, 4, 5-T were satisfactory when applied any time during the March to July period as well as during October and November. Water and 2, 4, 5-T alone gave a very low kill by the end of the first year.

Time Study of Axe and Machine Girdling

Time studies of girdling at the Bent Creek Experimental Forest showed that the oaks, red maple, and sourwood could be grouped together; hickory should be considered apart from the other species because the machine girdling time for hickory was nearly three times as long as for the other species (fig. 13). For the average-size hickory tree, the machine was slightly less than twice as fast as axe girdling. For oaks, red maple, and sourwood, the machine was nearly three times as fast as the axe. Travel time between trees and number of trees per unit area were not considered in this study, but general observations indicate that steep topography and a small number of trees per acre reduce the advantage of the machine over the axe.

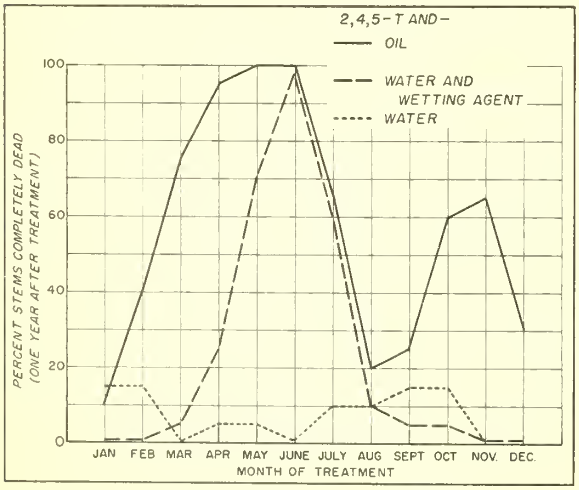


Figure 12.--Sweetgum kill using three mixtures of 2, 4, 5-T applied in frills at monthly intervals, Santee Experimental Forest, South Carolina.

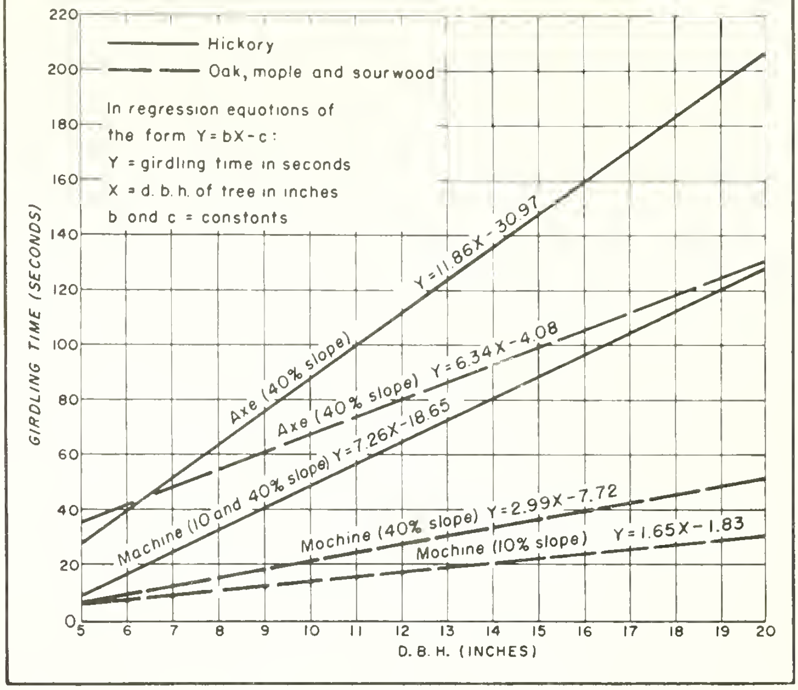


Figure 13.--Machine and axe girdling time per tree as affected by species, d.b.h. and steepness of slope, Bent Creek Experimental Forest, North Carolina.

Effect of Pruning on Height and Diameter Growth of Slash and Loblolly Pine

In order to establish limits within which pruning can be safely done without sacrificing rate of growth, a series of studies has been carried on during the past 10 years. One of these studies at the George Walton Experimental Forest at Cordele, Georgia, shows that up to 80 percent of the live crown of 5- and 11-year-old slash pine can be pruned with little or no effect on the height growth. Diameter growth was more sensitive to pruning than was height growth; diameter growth of pruned trees decreases rapidly with a decrease of from 50 to 10 percent crown ratio, but with ratios of more than 50 percent the decrease is very gradual.

Pruning studies at the Hitchiti Experimental Forest at Macon, Georgia, show results on loblolly pine similar to those in slash pine at Cordele. At Macon, the conventional pruning method caused a slight increase in height growth and a slight decrease in diameter growth when the treatment did not exceed two-thirds the total height of the tree. On the other hand, bud-pruning at both Macon and Cordele has reduced diameter growth of slash pine to as low as 50 to 69 percent of normal, while the height growth has been less affected (83 percent or more of normal). Both height and diameter growth of loblolly pine at Macon have been reduced about 50 percent by bud-pruning.

Pruning Highly Profitable for Both Slash and White Pine

A 19-year study of pruning white pine on the Toccoa Experimental Forest in north Georgia indicates that at 50 years after pruning, the profits from the pruning may be as high as $680 per acre on good sites. White pine normally retains dead branches on the butt log over most of the rotation, thereby producing low-quality lumber containing loose knots. Thus, it is very important that the butt-log lengths of young white pine be pruned (fig.14).

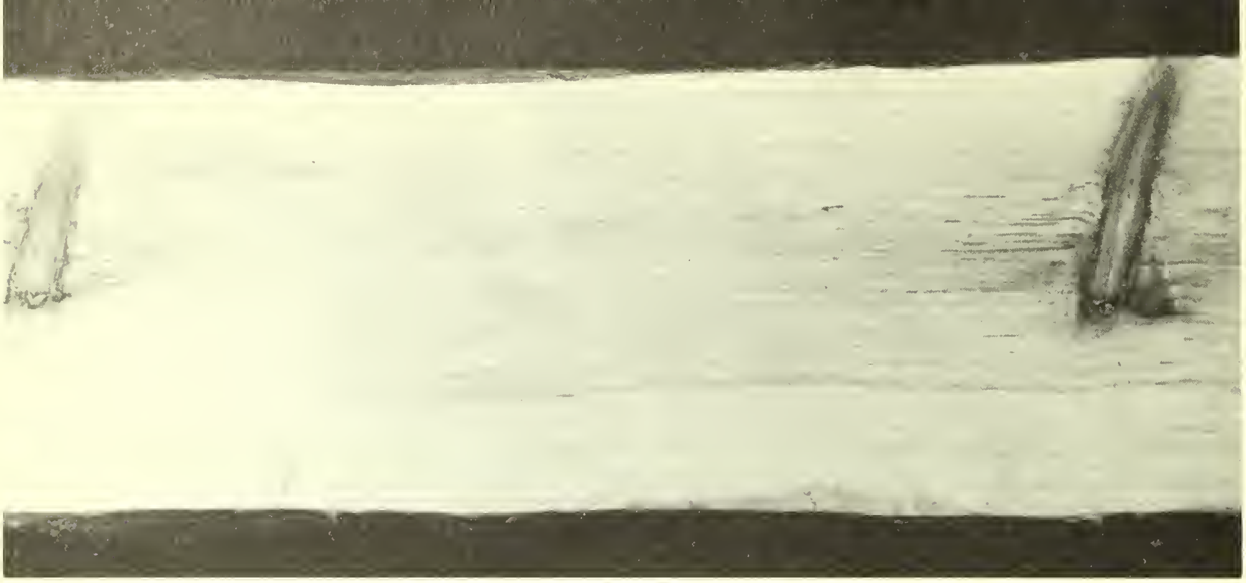


Figure 14.--Clear wood laid down in a 19-year period after pruning of white pine on the Toccoa Experimental Forest in northern Georgia. The wounds healed over in 1 to 5 years depending on the diameter of the branch. Average healing time was 3 years.

A study of pruning planted slash pine at Cordele, Georgia, shows that by pruning in two steps, at 6 and 11 years of age, a net profit of $267 per acre can be realized at the age of 52 years (41 years after the last pruning). On a basis of 5-percent interest compounded annually, table 6 shows how the costs and returns are computed for a pruned butt log.

Table 6.--Cost and returns for a pruned butt log of slash pine, Cordele, Georgia

D.i.b. at top of 16-ft. log (inches)	D.b.h.	Age	Volume			Pruning cost at harvest	Net return
			Total	Knotty	Clear		
	Inches	Years	- - - - Board feet - - -			Dollars	Dollars
10	12.8	28	65	27	38	.23	.91
12	15.2	36	95	27	68	.34	1.70
14	17.6	44	135	27	108	.50	2.74
16	20.0	52	180	27	153	.74	3.85

Growth of White Oak Sprouts Increased 50 to 100 Percent

One of the major problems of managing hardwoods is the proper treatment of sprout clumps. Natural thinning is very slow in white and chestnut oak stands, and it is not uncommon to find 40- to 50-year-old clumps with multiple stems. A study of thinning 25-year-old white oak sprouts to one stem per clump at the Lee Experimental Forest in Piedmont Virginia showed (6 years after thinning) that the growth rate was 50 to 100 percent higher on residual trees in thinned clumps than it was in unthinned clumps. The reduction of oak sprout clumps to a single desirable stem at an early age is also generally recommended on the basis of the resulting improvement of the quality of the stand.

Like most basic scientific research, silvical research is often only a stepping stone to either additional research or to some practical application in forestry. The need for increased basic forest research is as well recognized by most foresters as it is by the Station; accordingly the past year's work shows increased emphasis on silvical studies.

Site Index of Scarlet and Black Oak in Relation to Soils and Topography

In the Southern Appalachians a soil-site project is in progress for (1) correlating the site indices for various species on the same land and (2) relating the site index of species to physical properties of the soil and topography. In a recent study of the relationship of site index of scarlet and black oak to soils and topography it was determined that three properties of the soil and topography best express this relationship as given in the following regression equation:

$$Y = 38.7690 + 8.8057X_1 - .0477X_2 - .4620X_8$$

where: Y = site index

X_1 = depth of A horizon in inches

X_2 = position on slope in percent

X_8 = sand in A horizon in percent.

Site index, used in this study, is the height of the average dominant and codominant trees at 50 years of age. Figure 15 also shows the 3-dimensional effect of each of the three independent variables on site index. An examination of humus types revealed that they are also fairly good indicators of site quality on scarlet and black oak sites. Mor humus types usually occurred on the poorest dry sites, duff-mulls on intermediate sites, and true mulls on the best, moist sites.

Relation of Growth to Site Index and Density of Loblolly Pine

One of the most important and least known relationships bearing on southern forestry is that between stand density and growth rate of southern pines. Analysis of loblolly pine growth rates on a series of 43 thinning, shelterwood, and seed-tree plots in the Piedmont and Coastal Plain of Virginia and the Carolinas throws some light on this relationship. Within the rather narrow range of ages (25 to 35 years) and sites (70 to 80 feet) sampled, current growth in cubic feet per acre increased with stand density, but tended to level off above 60 square feet of basal area (fig. 16).

Reports on more comprehensive studies of the relation between stand density and growth of loblolly pine and slash pine are being prepared for publication during 1956.

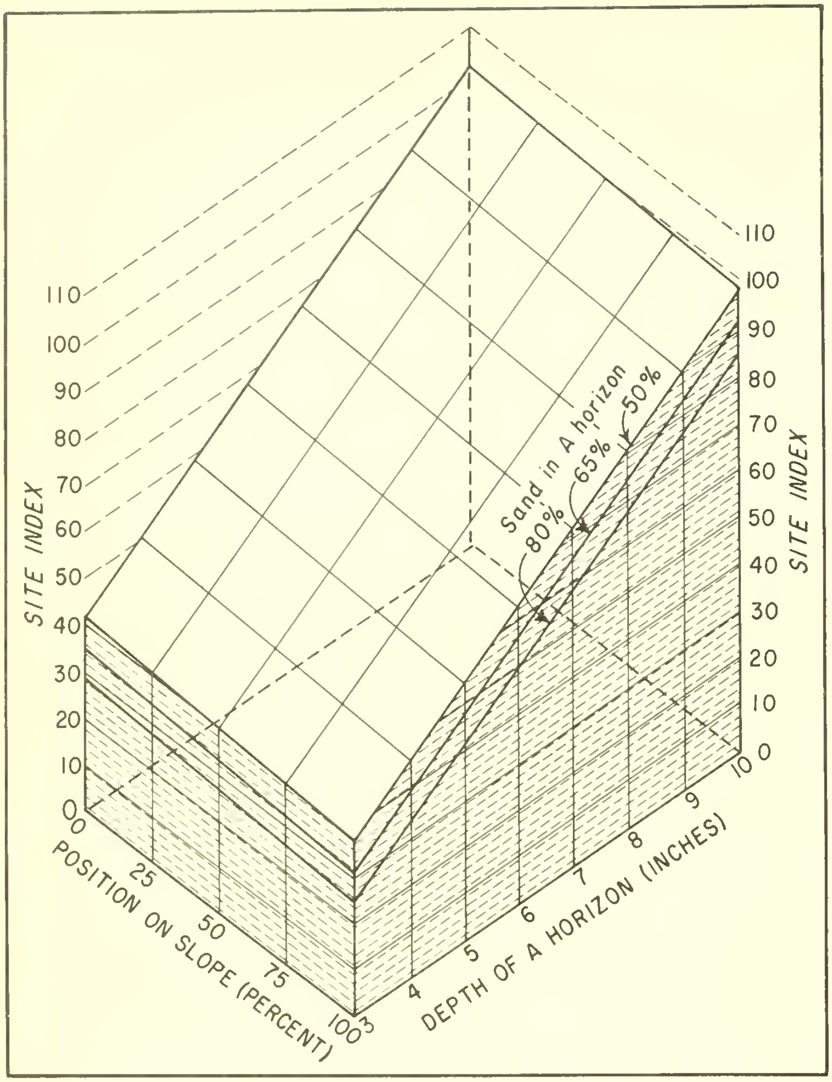


Figure 15.--Block diagram for site index of scarlet and black oak as related to depth of the A horizon, position on slope, and sand in the A horizon, Southern Appalachians.

Relative Growth Rates of Pine Seedlings and Hardwood Sprouts

Occasionally money is wasted releasing pine seedlings that would outgrow competing hardwoods without assistance. More often, release is not provided where it is really needed. Sound decisions on early release work require a knowledge of the relative early growth rates of pine seedlings and their competitors, which are usually hardwood sprout clumps. Information of this type for loblolly pine is given in figure 17. It applies to the sandy soils of the flatwoods in eastern North Carolina and Virginia. More information is given in Station Paper 55, "Growth and prospective development of hardwoods and loblolly pine seedlings on clearcut areas."

Turpentining Increases the Cone Crop of Slash Pine

Three consecutive years of cone-counting on the Olustee Experimental Forest in Florida indicates that turpentining does not reduce the production of cones on slash pine. In fact, the reverse is true. The 3-year cone crop on slash pine trees worked for naval stores was 50-percent greater than the crop on comparable round trees. The cone count was started $1\frac{1}{2}$ years after beginning turpentining. Similar tests on longleaf pine are as yet inconclusive.

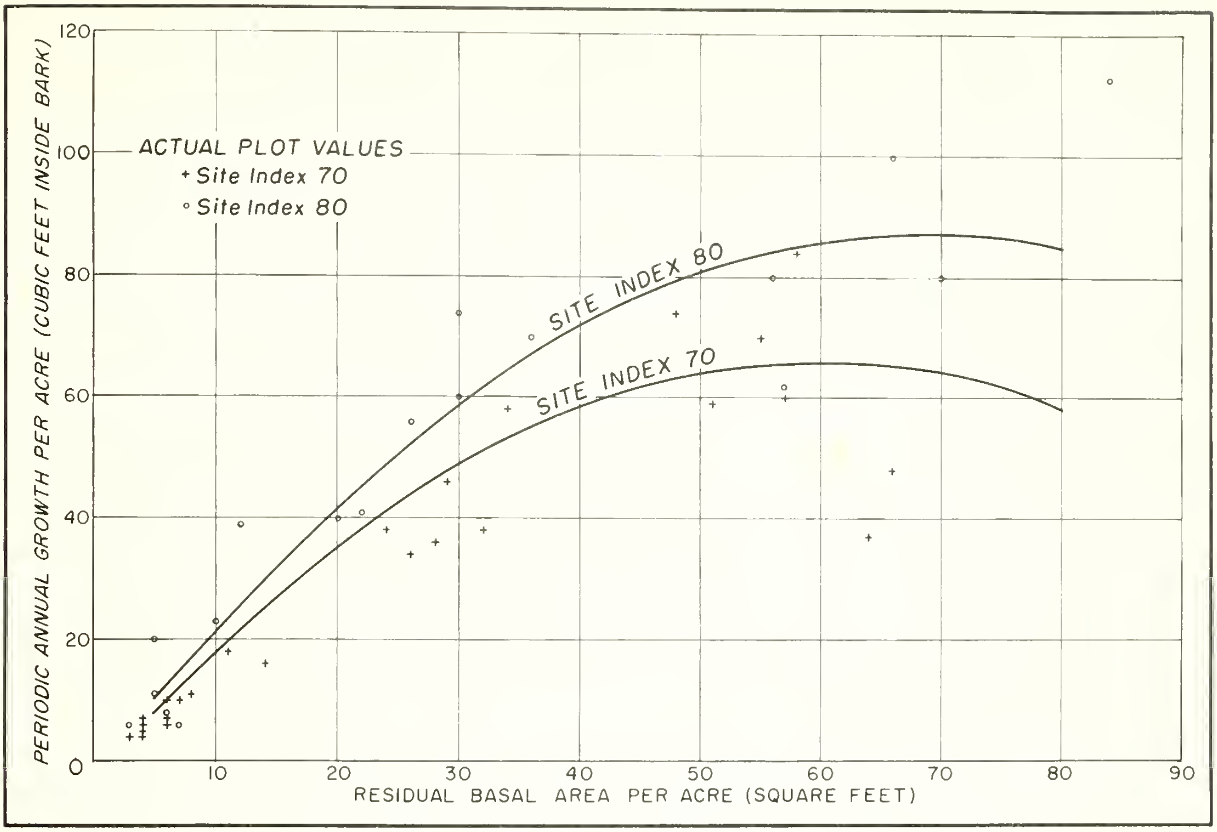


Figure 16.--The effect of site and residual density on periodic annual growth for a 9-year period after cutting in even-aged loblolly pine pulpwood stands.

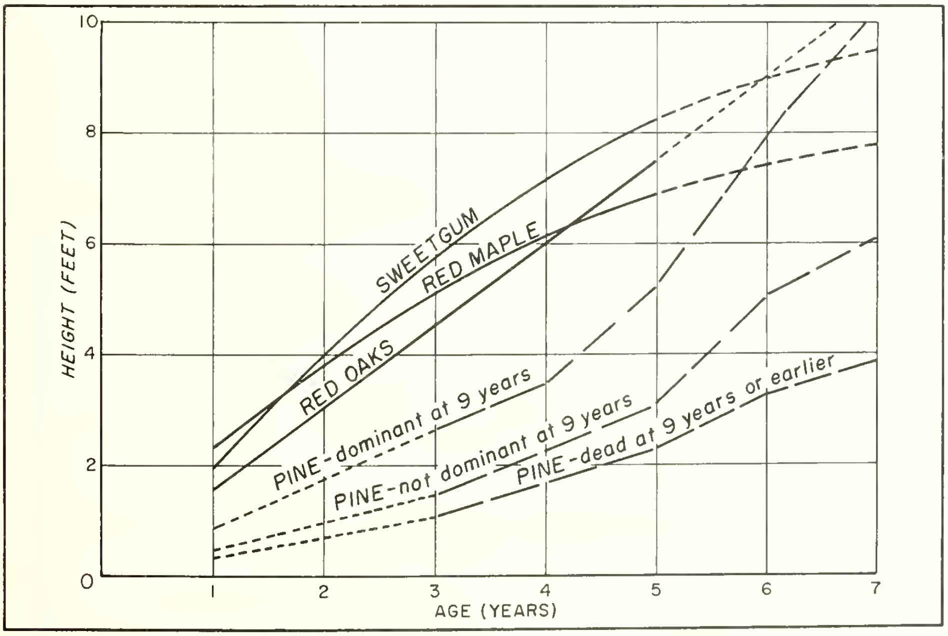


Figure 17.--Growth of hardwood sprout clumps and loblolly pine seedlings under average conditions.

The recent Timber Resource Review shows that while farmers own 60 percent of all commercial forest land in the Southeast, only one-third of their recently cutover woodlands is in the upper class of productivity. In other words, as the report puts it, "The future forest situation of the United States lies with the farmers and other non-forest industry private owners. They make up the heart of the forest problem." For these reasons, research most definitely should be geared to the problems of the small owner.

New Farm Woodlands Established in Piedmont Hardwoods

During the past year, four new farm woodland research and demonstration areas have been established in Piedmont hardwood stands: two in North Carolina and two in Georgia. In North Carolina both woodlands are located on Duke Power Company land, one near Mooresville and the other near Chesterfield and Morganton. The Mooresville woodland is typical Piedmont land and is forested with shortleaf pine, oak-hickory, and yellow-poplar (fig. 18). The Chesterfield woodland is in a zone of transition between the Piedmont and the mountains, and is forested with an oak-white pine-yellow pine type. These woodlands will be important show-windows in the new North Carolina Piedmont hardwood research project. This project is a joint effort of the Furniture, Plywood, and Veneer Council of the North Carolina Forestry Association, the Duke Power Company, and the Station.

Figure 18.--Mixed hardwood stand in the Mooresville farm woodland, which is better than average for the North Carolina Piedmont.

The new woodlands in Georgia are located near Athens on pine-hardwood forest lands of the University of Georgia.

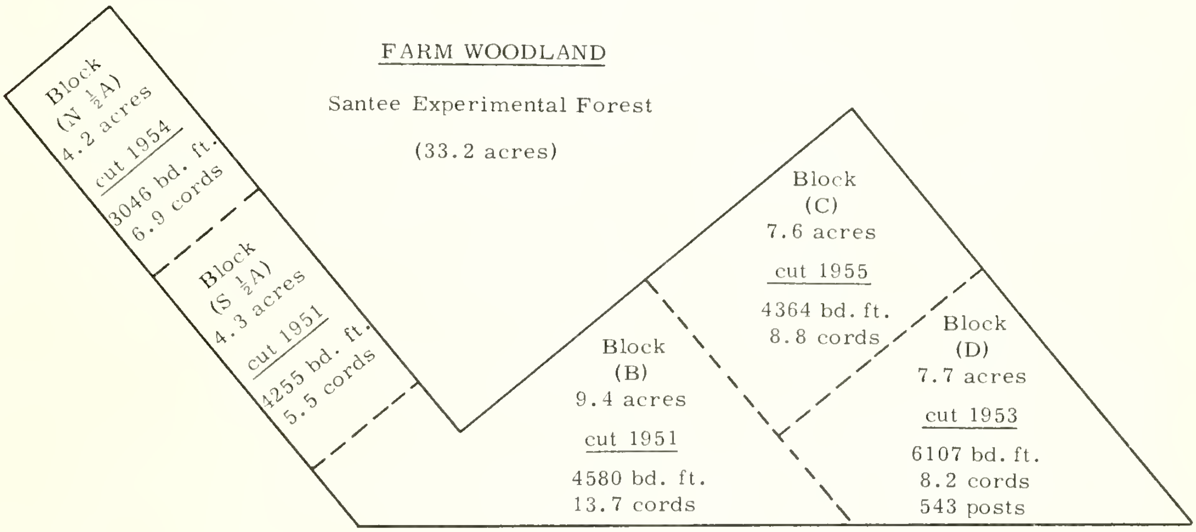
Summary of 5 Years of Farm Woodland Operation on the Santee

Farm woodland operations were started at the Santee Experimental Forest in coastal South Carolina in 1950. Now, after 5 years of annual cuts, complete records of the woodlands show that the productivity of these lands can be profitably increased by proper management. Figure 19 shows a stumpage value of nearly \$795 for the 33.2-acre woodland plus an earning of \$552.33 or \$1.02 an hour for the farmer's time spent in felling, bucking, and skidding the products

to the roadside--a total profit of $1,347.27 for the 5-year period, or $269.45 annually, or $8.12 per acre per year. Yet, in spite of these profits, the woodland was left in much better shape than before, not only in quantity but also in quality.

Yields of Gum From Farm Woodland

The fourth and final year of turpentining in the farm woodland at Cordele, Georgia, has been completed. Production has been above average, mainly because the trees are large (over 14 inches d.b.h.) with an average crown ratio of 66 percent. The average annual gum yield per face for the first 3 years was 13 pounds for a gross annual return of 76 cents and a net annual return of 36 cents per face.



SUMMARY OF 5 YEARS' OPERATION

5-Year Production

Sawlogs	22,352 bd. ft.[1]
Pulpwood	43.1 cords
Posts	543 pieces
Roadside value	$1,531.52
Stumpage value	- 794.94
Cash costs	- 184.25
Net for labor	$552.33, or $1.02 per hour

Stand Improvement

Planted	1.37 acres
Pine release	33.2 acres
Man-hours	110.5
Cash costs	$81.43

Stand per acre

1950	3,300
Present stand	3,550 bd. ft.

1/ All bd. ft. figures are Doyle log rule

Figure 19.--Summary of farm woodland operations during the period 1950-1955.

The problem of getting good forestry into practice often stems from a lack of knowledge of the financial aspects of forestry. Part of the answer to this problem can be demonstrated by research with farm woodlands, but the more important and basic answers must come from studies of lumber grade yields, tree and log grades, logging costs, and the business side of forest management.

Logging Costs by Volume Cut and Type of Cutting

In a 6-year summary of logging costs on the Bigwoods Experimental Forest there was very little range in the cost of logging (by Camp Manufacturing Company, Inc.) as related to the volume cut and method of cutting. Thus the removal of 6 seed trees per acre cost no more per unit volume than the removal of 5 times as much volume in 3-chain-wide clear-cut strips (fig. 20). And an annual selection cut removing less than one thousand board-feet per acre cost no more than the strip cutting. Prior to the seed-tree removals in the Bigwoods, such operations were considered inoperable, but now seed-tree removals are undertaken as readily as clear cuttings. The effect of this experience in forestry operations is very favorable--the lower the operable limit, the greater the variety of profitable cutting methods available to the forester.

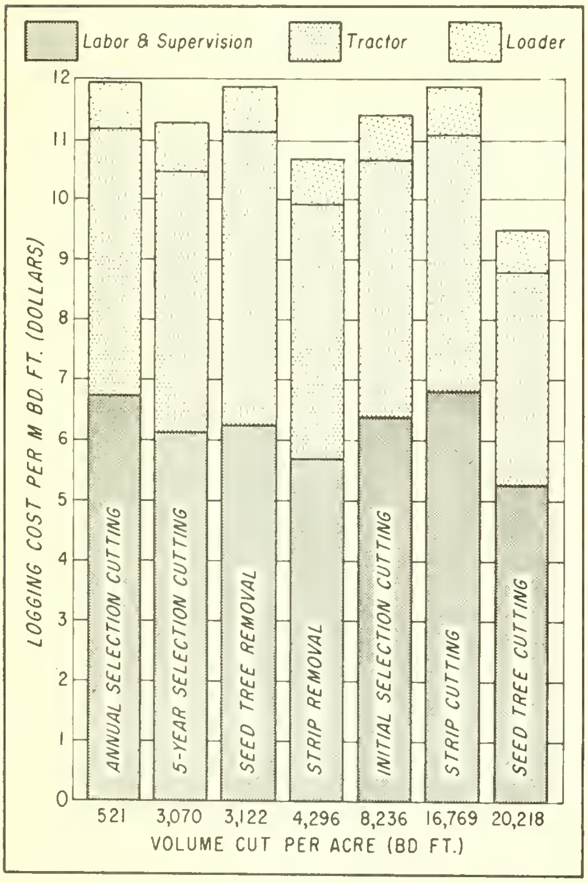


Figure 20.--Loblolly pine logging costs by volume and type of cutting, Bigwoods Experimental Forest, North Carolina. Each bar is an average of five to ten 35-acre compartments.

Study of Lumber Grade Yield by Southern Pine Log Grades

A grade yield study of loblolly pine on the Bonnie Doone Plantation near Walterboro, South Carolina, has provided additional information on the relation between log grades and lumber grade yields. The utility of log and tree grading is clearly illustrated in figure 21, where the percentages of high lumber grades follow closely the log grades from 1 through 4.

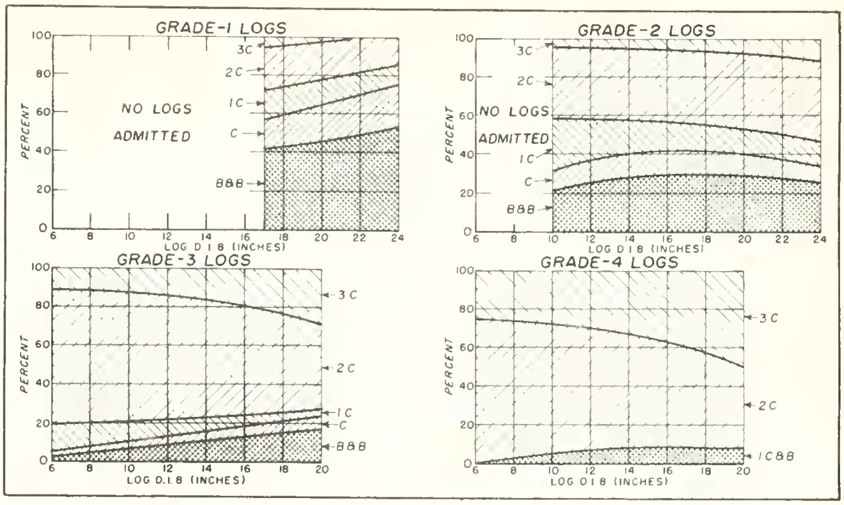
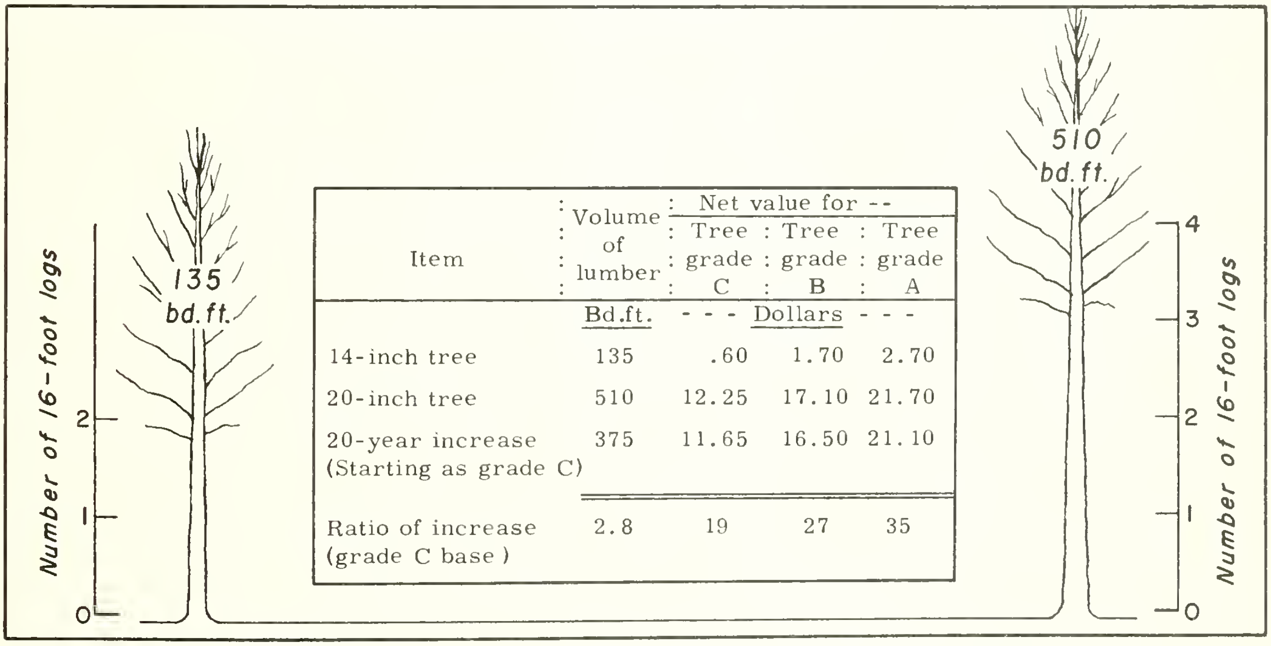


Figure 21.--Average percent of yard lumber grade recovery by log diameters and grades--loblolly pine type in the central Atlantic Coastal Plain near Walterboro, South Carolina.

Study of Yellow-Poplar Lumber Grade Yield

A recent grade yield study of second growth yellow-poplar in the Southern Appalachians shows how unwise it is to sell a 14-inch yellow-poplar tree. This size is the most profitable to hold because its value increases so rapidly with each added inch of diameter. For example, if a 14-inch grade C tree of Vigor Class I is held 20 years or until it becomes 20 inches d.b.h. and the grade changes to a grade B (as is likely), this same tree will be worth 27 times more than it was as a 14-inch tree (fig. 22).



Item	Volume of lumber	Net value for -- Tree grade C	Tree grade B	Tree grade A
	Bd.ft.	- - - Dollars - - -		
14-inch tree	135	.60	1.70	2.70
20-inch tree	510	12.25	17.10	21.70
20-year increase (Starting as grade C)	375	11.65	16.50	21.10
Ratio of increase (grade C base)	2.8	19	27	35

Figure 22.--Volume and value increase resulting from holding a 14-inch grade C yellow-poplar tree for 20 years, Southern Appalachians.

Growth and Economic Maturity by Species and Vigor Classes

Tree grades, vigor classes, and tree size at economic maturity are tools developed to serve as guides in choosing the right species and sizes of trees to cut or leave. Tree grades, of course, are also very important in improving the accuracy of appraisals. In a recent study of the economic maturity of Southern Appalachian hardwoods, growth and value data were used to compute the size at which trees of different species and vigor classes, cease to earn 3-percent compound interest. The results are given in table 7.

Table 7.--Growth rate and economic maturity of mountain hardwoods by species, vigor class, and log length
(In inches)

Species	Vigor class I		Vigor class II		Vigor class III		
	10-year growth	Maturity d.b.h.	10-year growth	Maturity d.b.h.	10-year growth	D.b.h. at economic maturity: 1 log	D.b.h. at economic maturity: 2 or more
Ash	3.20	29	2.00	24	1.20	19	18
Basswood	2.30	24	1.60	21	1.20	16	16
Beech	1.60	24	1.10	19	.80	18	18
Yellow birch	2.00	26	1.30	21	.80	19	19
Hickory	1.85	27	1.30	24	1.00	21	23
H. maple	2.30	24	1.50	20	1.00	16	15
R. maple	2.30	26	1.50	22	1.00	18	18
Y. poplar	2.80	26	1.85	23	1.40	18	18
Black oak	2.30	26	1.70	23	1.30	20	21
Scarlet oak	2.80	23	1.85	21	1.40	18	20
N. R. oak	3.60	30	2.30	25	1.70	22	22
Chestnut oak	2.10	25	1.40	21	1.00	21	21
White oak	2.10	25	1.40	20	1.00	18	19
Average	2.4	26	1.60	22	1.1	19	19
Range	1.6 - 3.6	23 - 30	1.1 - 2.3	19 - 25	.8 - 1.7	16 - 22	15 - 23

Tree Improvement and Genetics

Most of the Station's work in tree improvement and genetics is centered at Lake City, Florida, and Macon, Georgia. The Lake City project, financed jointly by the Forest Service and the Florida Board of Forestry, is concerned mainly with the development of superior strains of naval stores pines. The work at Macon, financed largely by the Georgia Forest Research Council, deals with selection and breeding among all the southern pines, with studies of racial variation, and with the development of seed orchards for the Georgia Forestry Commission.

Inheritance of Stem and Crown Characteristics in Slash Pine

Genetically speaking, slash pine is a mixture of good and poor traits as far as tree form is concerned. This species is widely planted and enormous quantities of seed are collected each year. Inasmuch as studies have shown that stem and crown characteristics (fig. 23) can be inherited, careful selection of trees from which seed is gathered is important.


Figure 23.--Common inherited forms of slash pine. A, Multiple-forked tree near Cordele, Ga. B, Short-branched tree on left with large branch angles, and long-branched tree on right with acute branch angles, Macon, Ga. C, Straight stem on left and crooked stem on the right, Cordele, Ga. The tree shown in A, the tree on the right in B, and the tree on the right in C are all undesirable forms.

Measurements of slash pine seedlings at the Ida Cason Callaway tree improvement project conducted in cooperation with the Station show that wide-crowned and slender-crowned mother trees have offspring remarkably like the parent, even though the pollen parent is unknown (fig. 24). This is the first evidence that branch length is strongly controlled genetically. Average crown width and the ratio of crown to tree height are given in table 8.

Table 8.--Average maximum crown width at one-third and two-thirds tree height for 3-year-old slash pine of different maternal parents

Type of parent or origin of stock	Total trees	Average tree height	Average crown width: 1/3 height	Average crown width: 2/3 height	Width/height ratio x 100: 1/3 height	Width/height ratio x 100: 2/3 height
	Number	Feet	Feet	Feet	Percent	Percent
Slender-crowned						
C-50	145	6.22	2.4	2.0	39	32
C-37	149	5.88	2.6	2.1	44	35
C-54	34	6.80	2.9	2.4	43	36
C-56	47	6.68	2.9	2.2	43	34
C-63	40	6.62	2.6	2.1	44	32
Broad-crowned						
C-4	44	6.54	3.6	2.6	55	39
C-10	179	6.40	3.5	2.5	55	39
Control seed 1/	75	6.18	3.3	2.4	53	39
Control seedlings 2/	65	5.40	2.8	2.2	52	40

1/ Seed obtained from commercial source and seedlings grown in the Foundation nursery.

2/ Seedlings obtained from a commercial source.

Racial Variation in Yellow-Poplar

A small study started 3 years ago at the Santee Research Center is giving some valuable information on the growth of yellow-poplar from the mountains of North Carolina as compared with that of the Coastal Plains. Early in the third growing season, seedlings of the mountain source were 4.4 feet in height and those from the coast of North Carolina were 7.9 feet, or nearly twice as tall (fig. 25).

Racial Variation in Pine

A comprehensive local seed-source study of loblolly pine was started by the Athens-Macon Research Center in cooperation with the Georgia Forestry Commission. Seedlings from 12 locations in Georgia, 3 in Florida, and 1 in Arkansas were planted in 9 different parts of Georgia, on lands made available by pulpwood companies and other cooperators. Early differences showed up in the nursery, where seedlings from Coastal Plain sources were slightly taller than those from inland sources.

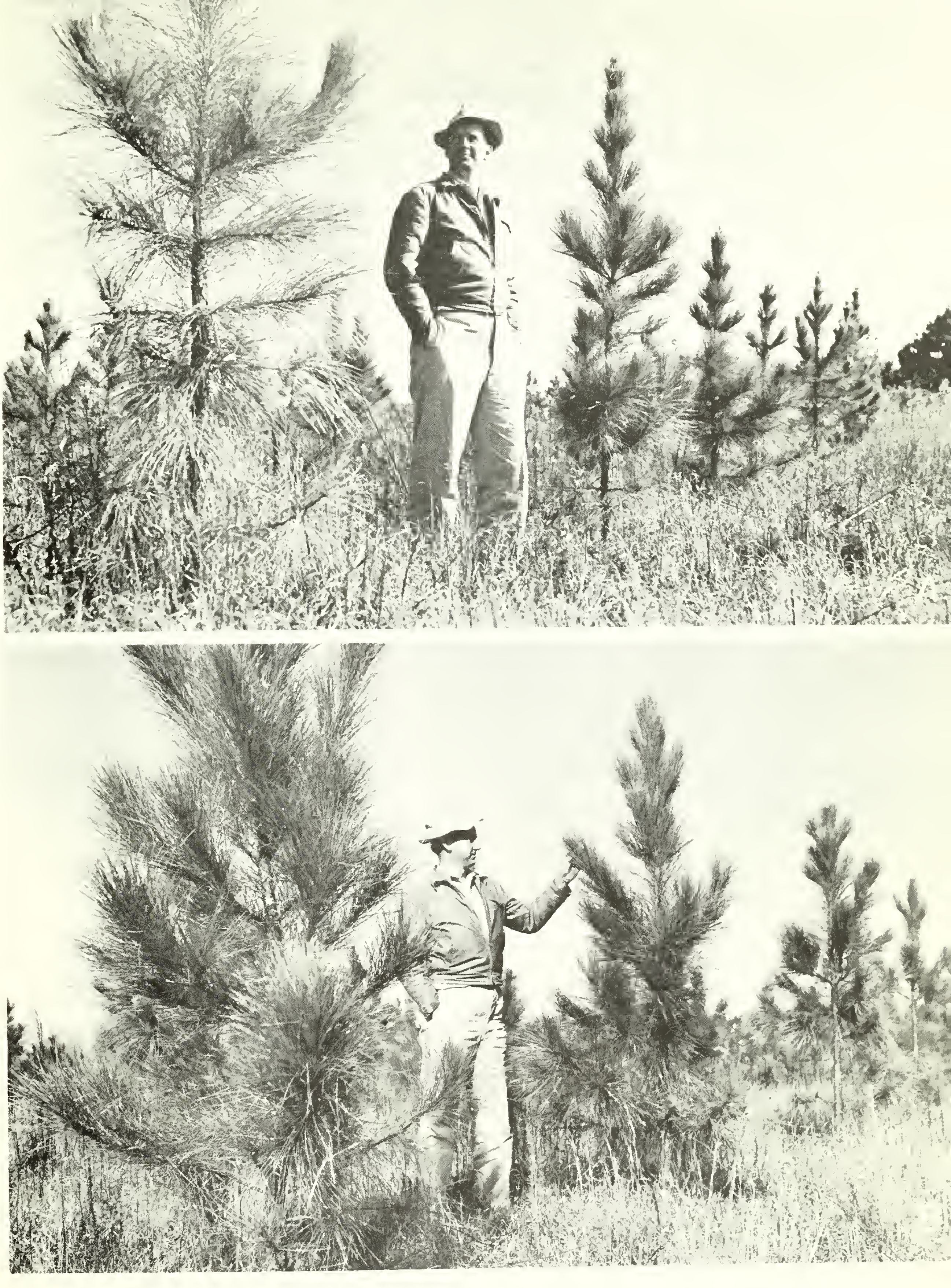


Figure 24.--Three-year-old outplanting of slash pine progeny at the Ida Cason Callaway Tree Improvement Project in Georgia. A, Seedlings from a slender-crowned mother have an average crown width of 2.4 feet. B, Seedlings from a broad-crowned mother have an average crown width of 3.4 feet.

Figure 25.--Yellow-poplar seedlings in a racial variation study at the Santee Research Center in South Carolina. The North Carolina mountain source at left is 4.4 feet in height, and the North Carolina Coastal Plain source at right is 7.9 feet early in the third growing season.

The Southern Appalachian Research Center is cooperating in an international study of racial variation in white pine. Seed collected last year will be exchanged with Experiment Stations in the Northeast, Central States, Lake States, and Canada, so that seed from all sources can be planted in each region.

Pine Seed Orchards are Being Established

A number of seed orchards and seed-producing areas are being established to produce seed of known parentage and to facilitate procurement of seed in the volume required for the Southeast's expanding planting program. Eleven million acres are in need of planting in the Southeast, and careful selection of the trees from which seed is obtained will reduce the proportion of crooked, forked, and heavy-limbed trees that now occur in many planted stands.

The largest seed orchard project is that of the Georgia Forestry Commission which is being installed cooperatively with the Station. Plans call for 500 acres of grafted stock of carefully selected loblolly and slash pine. The seed orchards are to be established at two locations in central Georgia. Progeny of each of the parent trees will be observed to insure that only mother trees of high quality remain in the orchard.

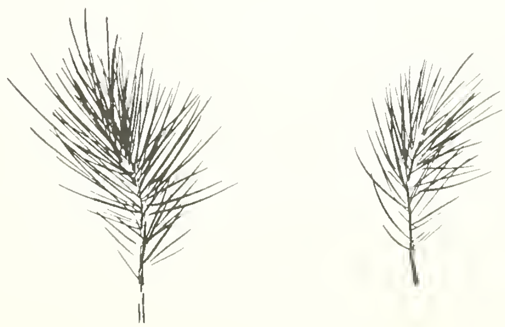
Age of Tree, Month of Treatment, and Concentration of Hormone Important in Air-Layering

Progress is being made in the development of efficient ways to propagate genetically superior pines. Air-layering (as described in previous reports) is regarded as a promising method in the Deep South although results have been poor at other places. A recent study at Lake City, Florida, showed the importance of the age of trees, concentration of root stimulating hormone, and month of treatment in air-layering slash pine. With a 1.2 percent concentration of indolebutyric acid applied in July, 80 percent of the air layers on 23-year-old trees rooted and 93 percent of the air layers on 6-year-old trees rooted. July treatments gave almost twice as many rooted air layers as September treatments, and the 1.2-percent concentration of indolebutyric acid was superior to lower concentrations.

Several comprehensive reports on grafting were published during the year, and an illustrated guide to tree breeding techniques was prepared in cooperation with the Southern Region of the U. S. Forest Service (fig. 26).

Research Program Gets New Facilities in Georgia

The Station's genetics and related research in Georgia was materially strengthened through cooperative arrangements with the Georgia Forest Research Council, the Georgia Forestry Commission, University of Georgia, and the Southern Region of the U. S. Forest Service. New facilities made available at the Georgia Forestry Center at Macon include nursery beds, a lathhouse, a cone-drying and seed-extraction plant, two greenhouses, a seed-testing laboratory, and laboratories for pathology, entomology, and genetics (fig. 27). About 6,000 bushels of pine cones can be dried in a short time in the cone-drying plant which is operated by the Georgia Forestry Commission. The seed-testing laboratory is operated as a cooperative project by the U. S. Forest Service and the Georgia Forestry Commission. Additional facilities are available at the School of Forestry, Athens.



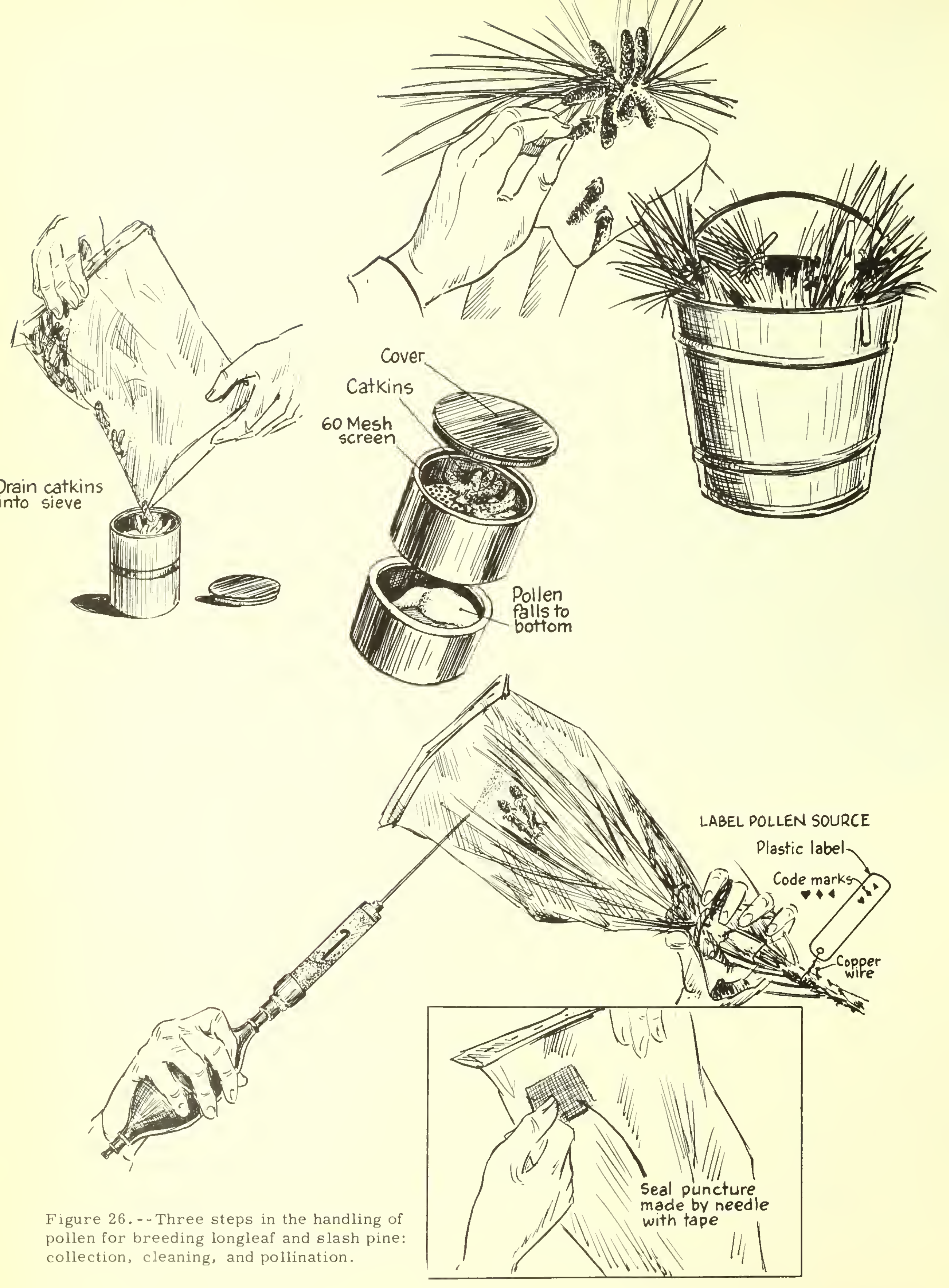


Figure 26.--Three steps in the handling of pollen for breeding longleaf and slash pine: collection, cleaning, and pollination.

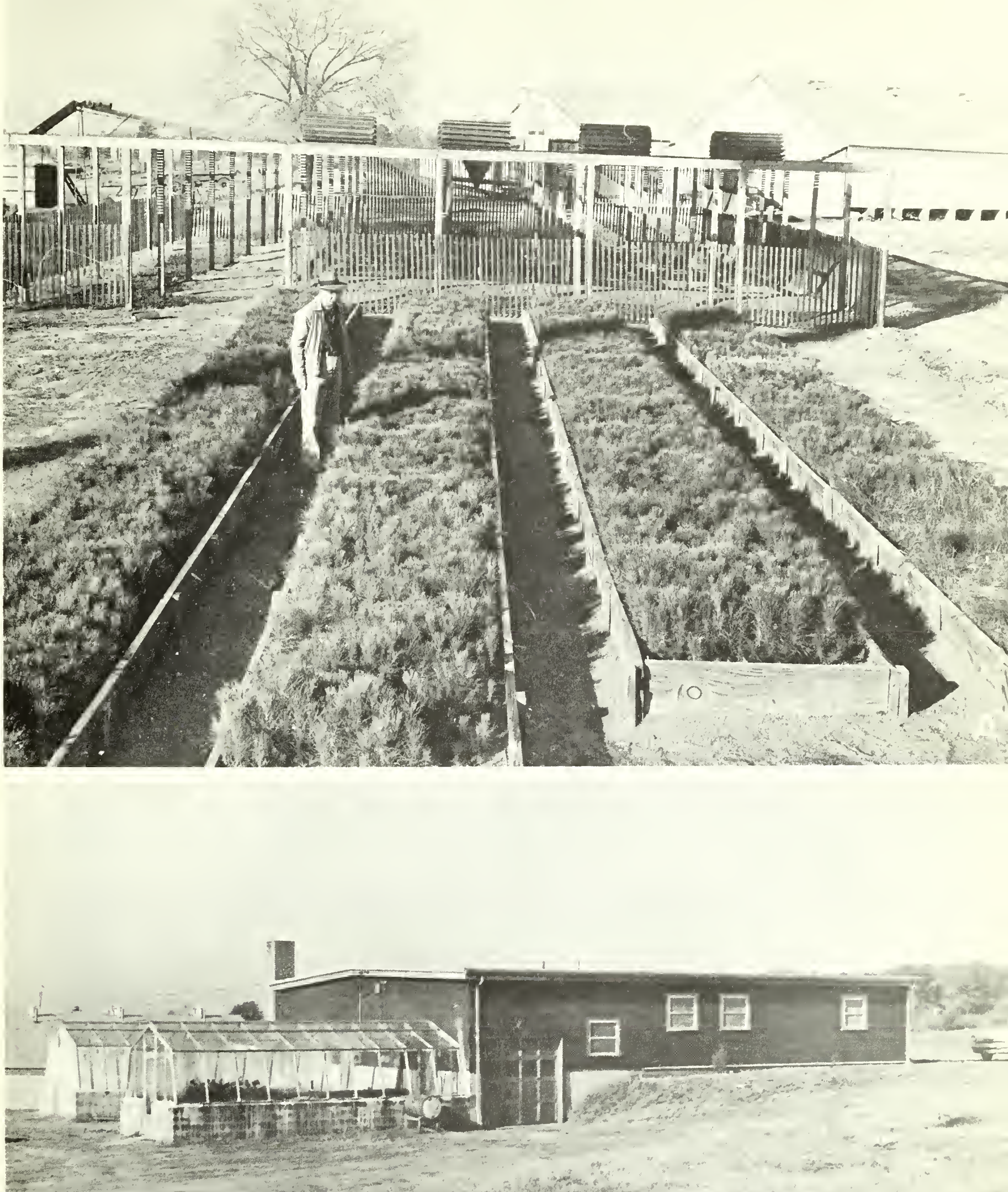


Figure 27.--Some of the facilities at the Georgia Forestry Center are shown above. A, Nursery beds and a lathhouse for the genetics project. Buildings in the background are part of the cone drying and seed extraction plant. B, Greenhouses and laboratories for pathology, entomology, genetics, and seed testing.

Naval Stores

The gum naval stores industry dates from the early seventeenth century. In the early days and up until 10 or 15 years ago, old destructive wood-chipping methods were used, and trees which had been turpentined were usually impaired in value for other wood products. Today, thanks mainly to bark chipping and sulfuric acid stimulation techniques, naval stores operations can readily be integrated with wood production. In fact, gum production usually returns at least as much profit per tree as wood products do.

New research developments in the genetics and physiology of naval stores pines promise still further increases in the profitability of turpentining and gum farming.

Gum Exudation Pressure Measured

A very important contribution to our understanding of the factors affecting gum flow was made during 1955. Gum has long been known to be under considerable pressure in the tree, but a satisfactory way of measuring this pressure has just been developed. The method is surprisingly simple, as shown in figure 28.

Now it is possible to measure all four of the variables specified in a previously derived equation for gum flow. The use of the pressure factor in addition to gum viscosity and size and number of resin ducts greatly increased the precision of the estimates of gum-yielding ability of different trees in tests made in 1955.

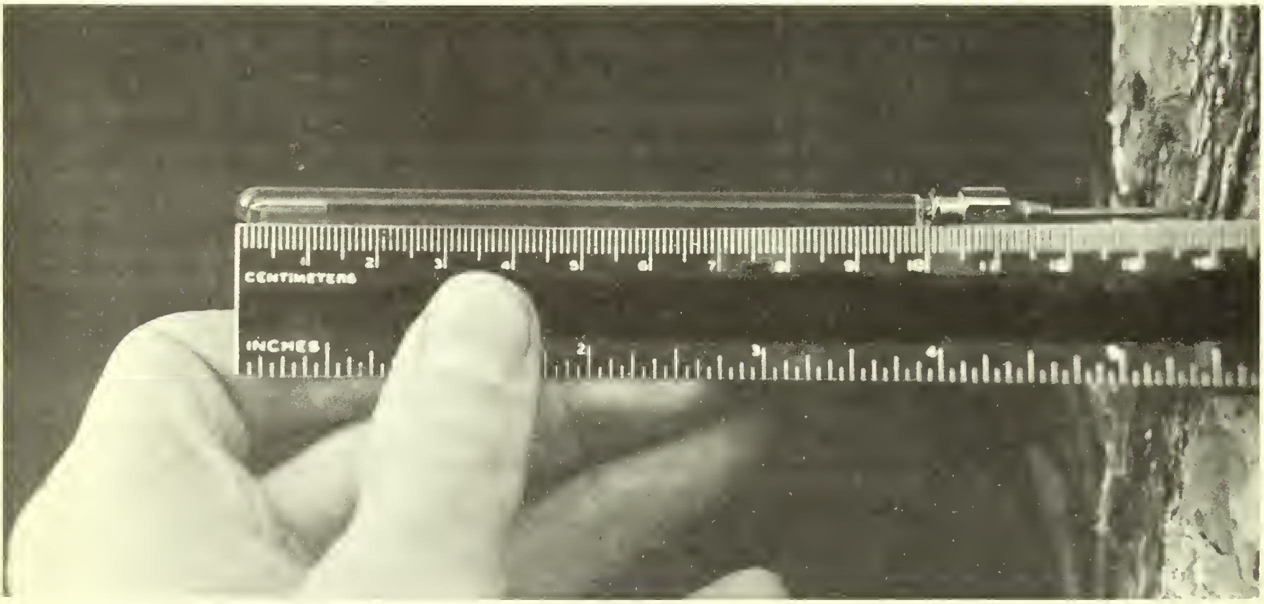


Figure 28.--Measuring gum exudation pressure in a slash pine tree at Lake City, Florida. A hypodermic needle is inserted through the bark into the outer rings of the sapwood. An empty capillary glass tube, sealed at the outer end, is fitted to the needle. The exuding gum compresses the air in the needle and tube. This tree shows a pressure of over 10 atmospheres (more than 150 pounds per square inch).

The new technique was used to determine the gum exudation pressure in parent trees and in their progeny at Lake City by Dr. Philippe Bourdeau of North Carolina State College. The tests revealed that this pressure is an inherited characteristic and that it is independent of viscosity of gum. Further, these two factors are independent of tree size. Hence the ratio of pressure to viscosity is a useful criterion for evaluating the gum-yielding ability of either parents or progeny.

Perhaps this diagnostic tool will be most useful in the selection of additional trees having high gum yields for seed-orchard establishment. In tests made to date on high-yielding parent trees, the only ones which had a high pressure/viscosity ratio were the three whose progeny had high average gum yields.

New Chemicals for Prolonging Gum Flow

Potassium alpha-naphthoxyacetate was reported recently to be an effective gum-flow stimulant. Testing at the Lake City Research Center, however, revealed that a concentration of 20 percent was essential for gum yields comparable to those obtained with 50-percent sulfuric acid on slash pine. On longleaf pine, penetration of the new chemical above the face was excessively high and erratic, and gum yields progressively declined during the season. These results are very similar to those previously obtained with a 2-percent solution of a water-soluble form of 2, 4-D. Hence salts of alpha-naphthoxyacetic acid cannot be recommended for naval stores use.

Intensive Chipping Methods Studied

Intensive extraction methods involving streaks $1\frac{1}{2}$ inches high treated with 65-percent sulfuric acid were tested on a pilot-plant scale on two commercial operations. Gum yields were 11 percent greater on longleaf pine and 15 percent greater on slash pine for the second year of work than with the standard extraction method involving streaks three-fourths inch high treated with 50-percent sulfuric acid. These treatments, however, appear to be more intensive than is necessary to get maximum gum yields on 2-year faces. Other studies indicate that increases in gum yields of this magnitude could be obtained with somewhat lower streak heights and 50-percent acid.

Equipment Development

If modern turpentining methods are to be used efficiently by the naval stores industry, adequate tools and equipment are needed for each job. To install and work a turpentine face and to collect the gum, twenty different items are needed. Many improvements in the more important of these items have been made by the Station's naval stores equipment research project and by others. Further modifications in design and standardization in the production of these items are needed.

During the past year, improvements were made in the combination tool for chipping high faces and spraying them with acid, and in the acid sprayer for low faces.

Figure 29.--An improved bark puller simplifies the pulling of streaks on high faces.

Pilot models of a newly designed cutting blade for a bark puller (fig. 29) were made and tested on commercial operations with the help of seven cooperating gum producers. All tests showed that the new design was satisfactory. Plans are being made to have this new puller blade available commercially in the spring of 1956.

The acid spraying mechanism of the combination spray-puller has also been improved (fig. 30). Weak points have been strengthened, leakage has been eliminated, and spray characteristics have been improved. New designs of the parts necessary to bring about these improvements have been submitted to the manufacturer of the tool.

Complaints from users of the acid spray bottle indicated that new bottles were hard to squeeze. This trouble was traced to a new thick-walled bottle substituted without notice by the manufacturer of the bottles on a delivery to the maker of the sprayers. Specifications were worked out for the original thin-walled bottle, which is now used with all sprayers.

Figure 30.--Laborer using a bark puller-sprayer in the fifth year of work. After 4 years of bark chipping and acid treatment combined with the use of spiral gutters and double-headed nails, the quality of the butt log has not been seriously impaired.

FOREST ECONOMICS

Progress on the Forest Survey

During 1955, field work on the Forest Survey was completed in the Northern Coastal Plain and the Mountain Region of North Carolina (fig. 31). Statistics compiled for the Northern Coastal Plain area were published in June, and those for the Mountain Region are now ready for publication. Field work in the Southern Coastal Plain was completed late in 1952, and the data were published in 1953. Work is continuing in the Piedmont area and should be finished early in 1956.

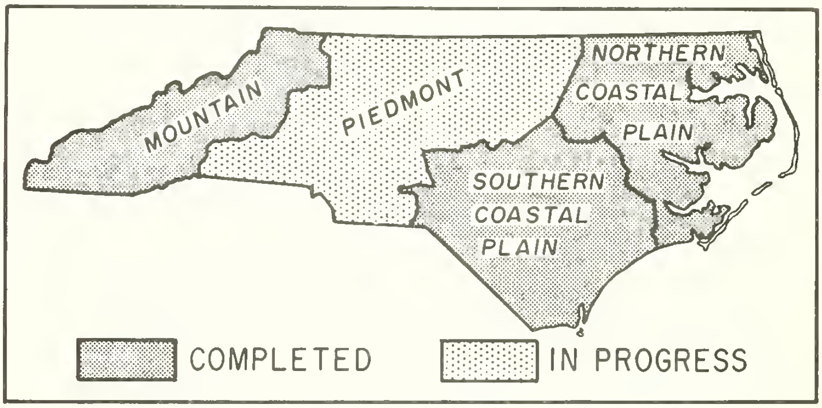


Figure 31.--Progress of the Forest Survey in North Carolina.

Changes and Trends in Western North Carolina

The resurvey of the Mountain Region of North Carolina discloses a number of important trends and changes since the first survey in 1938.

The Mountain Region is the most heavily forested section of the State. Four out of every five acres are now under some type of forest cover. The trend in land use has been toward a greater acreage of forest and less area in agriculture. In the past 17 years, 526,000 acres have reverted to forest, increasing the total area by 14 percent.

Public agencies own 1.3 million acres, or 30 percent of the forest land. Largest holdings are in the Pisgah and Nantahala National Forests, and in the Great Smoky Mountains National Park. The remaining 70 percent in private ownership is divided between farm woodlands and industrial and other private holdings as shown in figure 32.

The gain in forest area between surveys shows up principally as an increase in the area of hardwood timber stands. As shown in figure 33, one-half million acres were added to the area of hardwood types during the period. Two softwood types increased, but the shortleaf pine type decreased by over 150,000 acres. The net change in softwood type area was a loss of 55,000 acres.

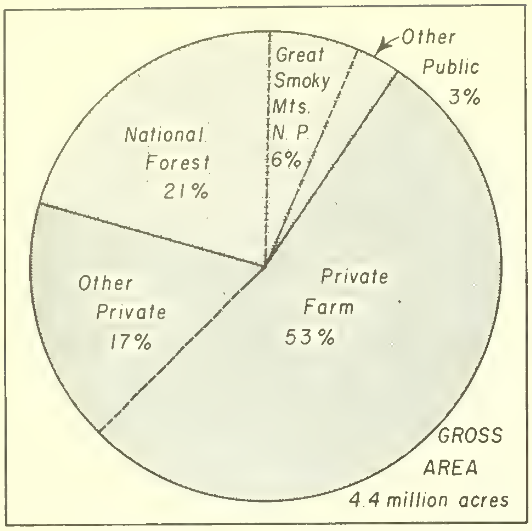


Figure 32.--Ownership of forest land, 1955.

Sawtimber volume is 22 percent greater than it was in 1938. It has increased 1.6 billion board-feet to the present total of 8.7 billion. Southern yellow pine volume shows a loss of 14 percent (table 9), but the other species groups have made substantial gains.

The level of growing stock shows a sharp, even surprising, increase since 1938. The present volume of 2.9 billion cubic feet of wood in sound trees is 40 percent higher (table 10). Yellow pine volume remains unchanged, while

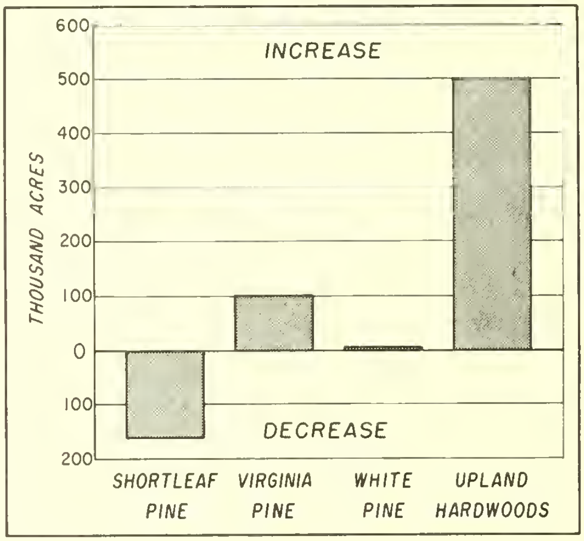


Figure 33.--Change in area of forest types, 1938 to 1955.

Table 9.--Comparison of sawtimber volume, 1938 and 1955

Species group	1938	1955	Change	
	Million bd. ft.	Million bd. ft.	Million bd. ft.	Percent
Yellow pines	1, 154	991	-163	-14
Other softwoods	1, 116	1, 449	+333	+30
Hardwoods	4, 835	6, 236	+1, 401	+29
	7, 105	8, 676	+1, 571	+22

Table 10.--Comparison of volume in all trees 5.0 inches d.b.h. and larger, 1938 and 1955

Species group and class of material	1938	1955	Change	
	Million cu. ft.	Million cu. ft.	Million cu. ft.	Percent
Growing stock:				
Yellow pines	384	384	0	0
Other softwoods	229	307	+78	+34
Hardwoods	1,477	2,228	+751	+51
All species	2,090	2,919	+829	+40
Cull trees:				
Yellow pines	49	104	+55	+112
Other softwoods	15	45	+30	+200
Hardwoods	555	864	+309	+56
All species	619	1,013	+394	+64
All live trees	2,709	3,932	+1,223	+45

the increases in growing stock of other species groups are similar to the change in sawtimber volume. The amount of material in cull trees is also up. Many of these cull trees can be utilized for pulpwood, fence posts, or other products where clear length and straightness are not limiting factors.

Hardwood Trends in Central and Northern Georgia

Landowners in central and northern Georgia know only too well that for many years hardwoods have been replacing pine in their timber stands. A recently completed analysis of Forest Survey information for this area points up the extent and nature of this shift from pine to hardwoods.

The trend is toward more forest land, and toward more forest area in hardwood types. Between 1936 and 1953, the area of forest increased by 2.3 million acres, or 21 percent. Pine became established on much of this new forest land, but this increase in pine type was more than offset by the reversion of pine type to oak-pine and hardwood on other forest areas. Hardwood type now makes up 38 percent of the forest area compared to 26 percent in 1936.

Further shifts from pine to oak-pine and hardwood types can be expected. Nearly all pine stands in this area have hardwoods in them, but the proportion of hardwoods is especially large in the understory. About half the 2-inch trees in shortleaf and loblolly pine stands are hardwoods, and 80 to 90 percent of the 2-inch trees in oak-shortleaf pine stands are hardwoods.

Hardwood volume is increasing in this area, but its quality is decreasing. The average size of timber is getting smaller, the proportion of volume in less desirable species is increasing, and the proportion of volume in low-grade or cull trees is increasing. In 1936, 41 percent of the hardwood growing stock volume was in trees 16 inches and larger; now this proportion is only 30 percent. The less desirable oaks and hickory made up 47 percent of the volume in hardwood trees 16 inches and larger in 1936; they now make up 59 percent. Also, the proportion of total hardwood volume in cull trees has increased from 24 percent in 1936 to 34 percent in 1953.

Stemming the tide of low-quality hardwoods in central and northern Georgia presents a real challenge to forest landowners and forest industries in this region. One approach is to try to find a use for 113 million board-feet of surplus oak and hickory sawtimber growth (fig. 34). Also, forests are growing 544,000 cords of oak and hickory poletimber; only 134,000 cords are now being used. Just to keep the volume of cull hardwoods from increasing would mean cutting over a million cords annually. In addition to the annual growth, there is the present volume of nearly 30 million cords of cull hardwoods that should be removed from the stands to make room for better timber.

Landowners are faced with the problem of what to do about this ever-increasing volume of hardwoods while they are waiting for markets to develop. They have the choice of allowing these undesirable trees to take over more and more of the growing space, or destroying them. Some idea of the job involved in destroying them may be gained from the average number of cull trees per acre by tree diameter and forest type (table 11). Thus, to rid the average oak-shortleaf pine stand of all hardwood culls 5.0 inches and larger would mean killing 27 trees per acre, most of them under 11.0 inches in diameter. Many of these small cull trees are growing very rapidly, so that each year treatment is delayed they take up more of the available growing space and become more costly to remove.

Table 11.--Number of cull hardwood trees per acre by diameter and forest type in central and north Georgia

Tree diameter (inches)	Forest type			
	Oak hickory	Oak gum	Oak-loblolly pine	Oak-shortleaf pine
2-4	211	193	185	168
6-10	33	32	18	24
12-14	4	4	2	2
16+	2	3	1	1
Total	250	232	206	195

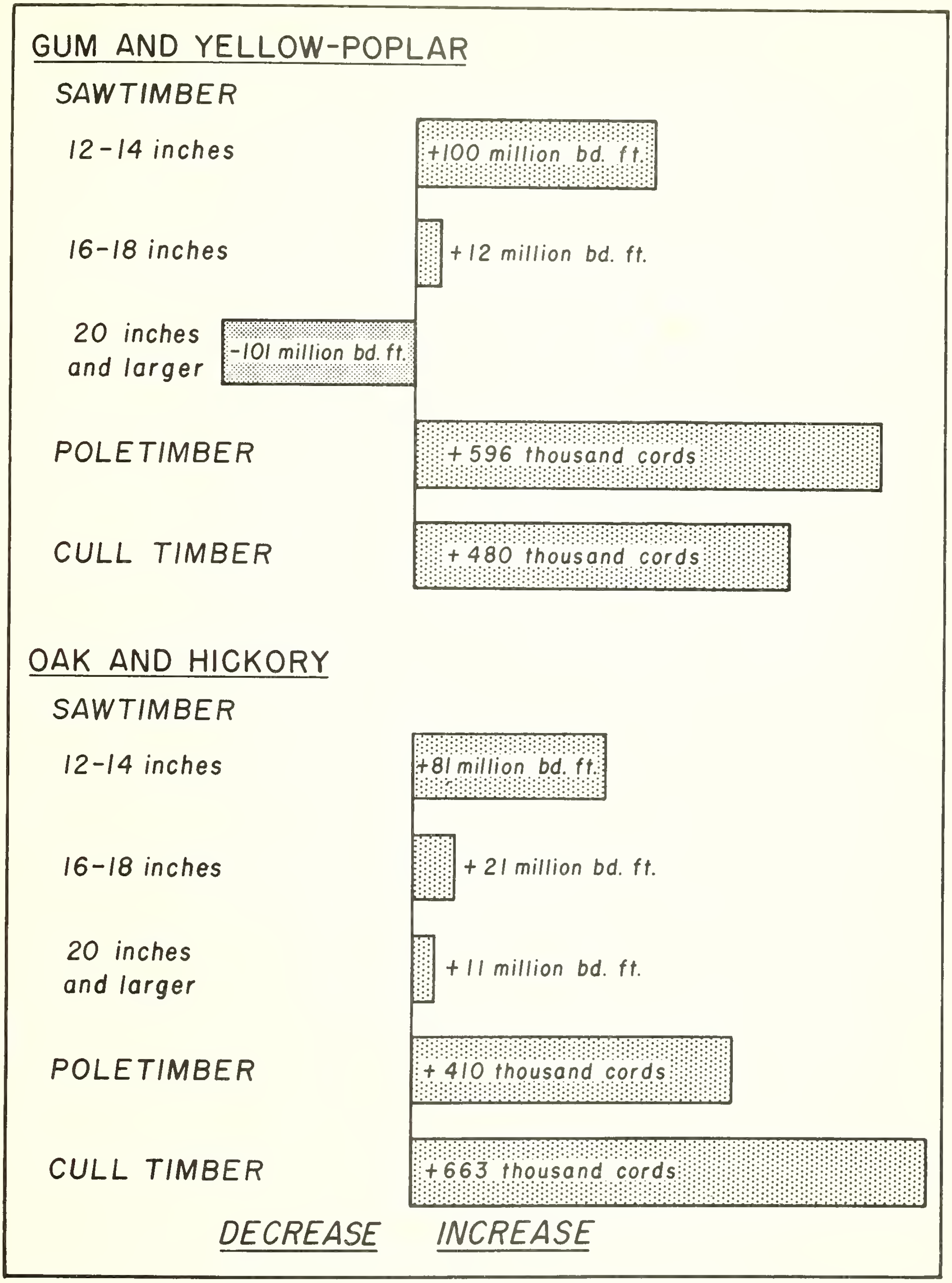
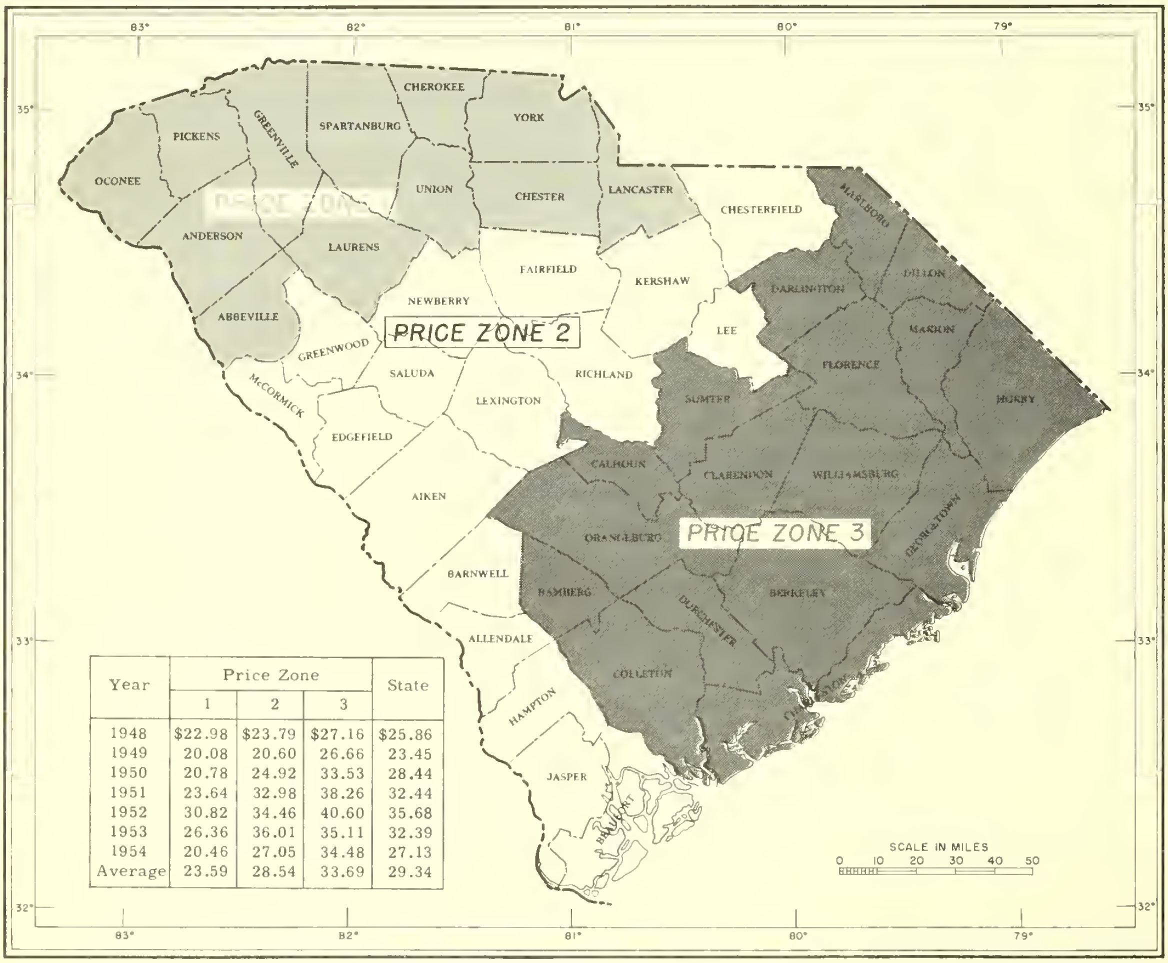


Figure 34.--Current annual change in volume of hardwood timber by size and class of material in central and northern Georgia.

Price of Pine Sawtimber in South Carolina

Most timber sellers are aware that buyers of pine sawtimber stumpage pay more for stands of large trees and for stands with a heavy volume per acre. The extent to which these stand characteristics affect price was shown by an analysis of stumpage prices paid for pine sawtimber marked by service foresters in South Carolina between 1948 and 1954.

Since stumpage prices, on the average, were lowest in the upper Piedmont and became progressively higher toward the coast, the State was divided into price zones. Over the period studied, the Zone 1 price was about five dollars below that in Zone 2, and the Zone 3 price was about five dollars above (fig. 35).



Year	Price Zone 1	Price Zone 2	Price Zone 3	State
1948	$22.98	$23.79	$27.16	$25.86
1949	20.08	20.60	26.66	23.45
1950	20.78	24.92	33.53	28.44
1951	23.64	32.98	38.26	32.44
1952	30.82	34.46	40.60	35.68
1953	26.36	36.01	35.11	32.39
1954	20.46	27.05	34.48	27.13
Average	23.59	28.54	33.69	29.34

Figure 35.--Pine sawtimber stumpage prices by zone, South Carolina, 1948-1954.

The average volume of all trees marked had the greatest effect on price of any stand characteristic tested. Regardless of the level of prices or the price zone, more was paid for stands where the average volume per tree was large than when it was small (fig. 36). In Zone 2, for example, the average price paid for pine stumpage in 1954 was $27.05 per thousand

board-feet. But sellers whose marked trees averaged 50 board-feet (roughly 11 inches d.b.h.) received only $24.12, compared with $27.67 for those whose marked trees averaged 200 board-feet (roughly 17 inches d.b.h.). In Zone 1 the difference--$9.29--was even greater, but in Zone 3 the difference was only $3.14.

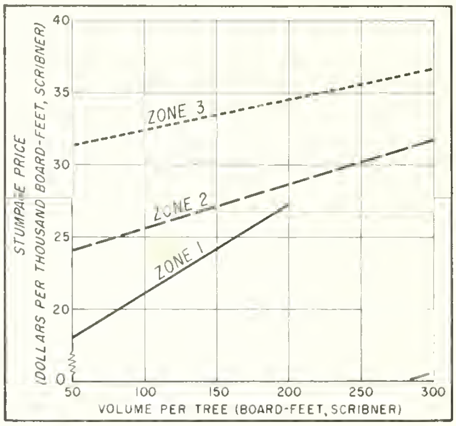


Figure 36.--Relation of pine sawtimber stumpage price to volume per tree by price zone, South Carolina, 1954.

The only other stand characteristic that significantly influenced price was volume marked per acre. The effect of this variable was less than for the average volume per tree. Nevertheless, the average price paid in Zone 2 for stands with 6,000 board-feet marked per acre was $2.80 per thousand greater than for stands with only 1,000 board-feet per acre (fig. 37). The differential for the same size stands in Zone 1 was $10.34, and Zone 3, $4.84.

Costs of Slab Salvage Methods Compared

Slabs and other sawmill residues, formerly of little value, are becoming increasingly important as a source of wood for pulping in this region. However, the development of the slab salvage program to date has depended primarily on the installation of expensive log barking and chipping equipment at the larger sawmills. Little progress has been made in the marketing and utilization of residues at the scattered, small sawmills that produce three-quarters of all the potentially chippable material (fig. 38). A current project at the Station is an appraisal of the comparative efficiency of various possible methods for procuring, transporting, and processing small-mill residues for pulping.

For convenience in figuring costs, all the salvage methods to be investigated have been reduced to their common operational components, namely: debarking, chipping, handling, and truck and rail transportation. Cost estimates based on published information, data from machinery manufacturers and users, and original studies are being prepared for each

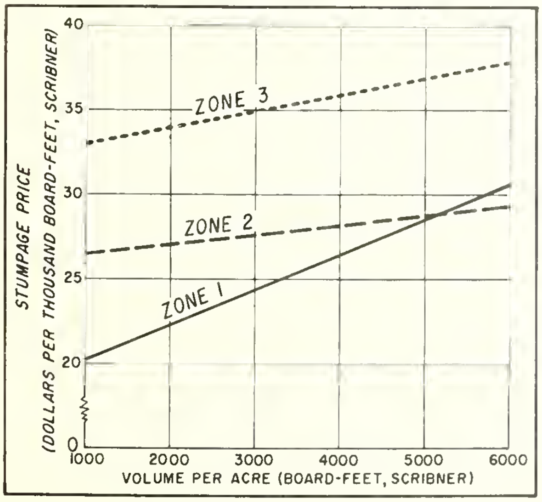


Figure 37.--Relation of pine sawtimber stumpage price to volume per acre by price zone, South Carolina, 1954.

Figure 38.--Sawmills like this produce three-quarters of the slabwood in the Southeast.

of these components. Once the component costs are available, they can be used in appropriate combinations to estimate the cost of bark-free chips under each method of salvage.

Although the cost analysis is not yet complete, a few tentative conclusions can be drawn. First, the cost (including trucking) of chips from residues produced at small sawmills is certain to be substantially higher than for chips from large sawmills. A minimum cost of about $8.00 per unit (of 210 cubic feet) loaded on railroad cars or trucks is indicated. This is at least $3.00 less than actual costs experienced to date. However, with chips now bringing $12.75 and $13.00 per unit, this would still leave a satisfactory operating margin for the more efficient operations.

The critical cost of salvaging small-mill residues is the cost of hauling them from the sawmill to the first destination--a pulp mill, a concentration yard, or a rail siding. In the first place, the delivered cost of residues is likely to be large compared to the cost of debarking and chipping them.

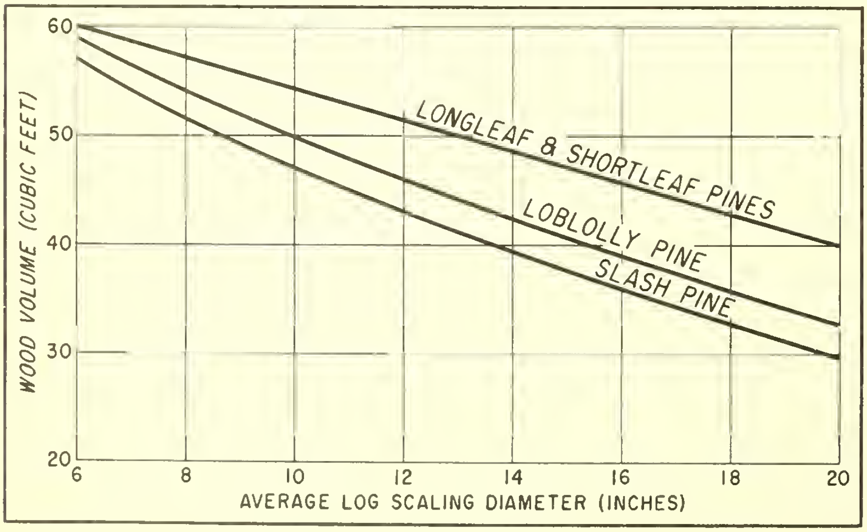


Figure 39.--Volume of wood per cord of rough pine slabs, by log diameter and species.

Secondly, as the volume delivered to a location is increased, the added cost of hauling longer distances will soon overbalance any economies of large-scale processing. This should prove an effective barrier to the establishment of big slabyards or chipping plants in the Southeast. On the basis of incomplete data, it would appear that yards capable of debarking and chipping about 30 cords per 8-hour day might be the most profitable. The same volume limitation would not apply to residues hauled directly to pulp mills, since no handling or reshipping costs would be incurred enroute.

Solid Content of Piled Slabwood

Slabs are customarily measured in cords. Therefore, to estimate salvage costs, one must know the amount of pulpable material in a cord of slabs.

An average cord of southern pine slabs contains 79 cubic feet of wood and bark. Of this, about 50 cubic feet is wood, and the rest bark. But wood volume varies both by species and diameter of logs from which the slabs came, as shown in figure 39.

WATERSHED MANAGEMENT

Always popular with visitors, the Station's watershed investigations, now limited to two work centers, are contributing to a better understanding of forest land management for water production and related purposes.

During the year, a small increase in funds was available for watershed management studies at the Coweeta Hydrologic Laboratory in western North Carolina. On this 5,700-acre drainage, basic record collection continued for 31 stream gages, 7 water-table wells, 17 recording and 93 standard rain gages, and numerous measurement stations for observation of soil moisture, stream temperatures, turbidity, and weather. A major accomplishment was the installation of prescribed treatments on six experimental watersheds, including such cover alteration measures as tree planting, deadening timber stands, and making a first timber improvement cut. Many years of records were also brought up to date by means of a labor-saving streamflow integrator. Work at the Piedmont Center in South Carolina, though handicapped by limited manpower, continued on the problems and hydrologic effects of rehabilitating wornout lands.

Increasing Water Yield by Cutting Forest Vegetation

Mounting concern about water shortages finds expression in many ways, including a growing number of inquiries to the Station as to how timber cutting may affect water supplies.

Studies at the Coweeta Hydrologic Laboratory have demonstrated that water yields definitely can be increased by cutting old-growth hardwood stands in the high rainfall country of the southern Appalachians, although the magnitude and duration of these increases will vary with the watershed, the cover type, and other factors. This year, some new light was cast on these relationships when water-yield data from three experimental watersheds were re-analyzed to obtain a more precise measure of the changes occurring after cutting treatment.

Among other things, the new analysis revealed that increases in flow after cutting are partly attributable to variations in rainfall. When adjusted for the precipitation variable, the annual increases in water yield, which may fluctuate considerably from year to year, are smoothed out. In effect, the adjustment involves correcting the observed increases in streamflow for variations above and below the mean precipitation for the watershed; and it affords new estimates of the increase as well as new concepts of the time trends involved.

The largest sustained increases in streamflow were obtained on Watershed 17, where all tree and woody vegetation was cut as well as all subsequent regrowth. The first year, the increase in high-quality water totalled 17 inches, equivalent to a volume 17 inches deep over the entire watershed. In the second year after cutting the regrowth for the first time, many herbaceous plants, low briars, and vines began to invade the area. Under this type of cover, the increase in water yield (smoothed out as described above) leveled off after the third year to about 11 area inches, as shown in figure 40.

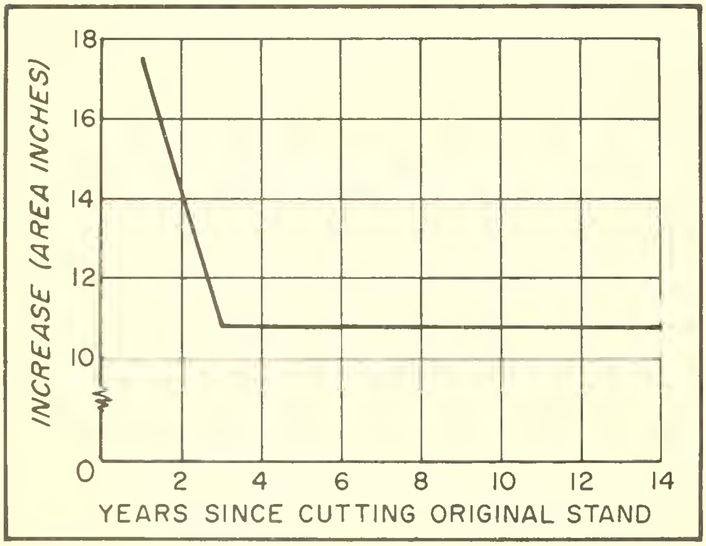


Figure 40.--Increases in water yield (adjusted for precipitation variable) after cutting a hardwood forest and subsequently all woody sprouts each year, Watershed 17.

Watershed 13 was cut initially in a similar manner but with the forest allowed to come back through sprouting and natural regrowth. The water-yield increase the first year was in the same magnitude as that from the other clear-cut forest. This increase diminished in succeeding years as the trees grew back, but it was still 4.4 inches above pretreatment yields in the 15th year after cutting, as shown in figure 41. Projecting

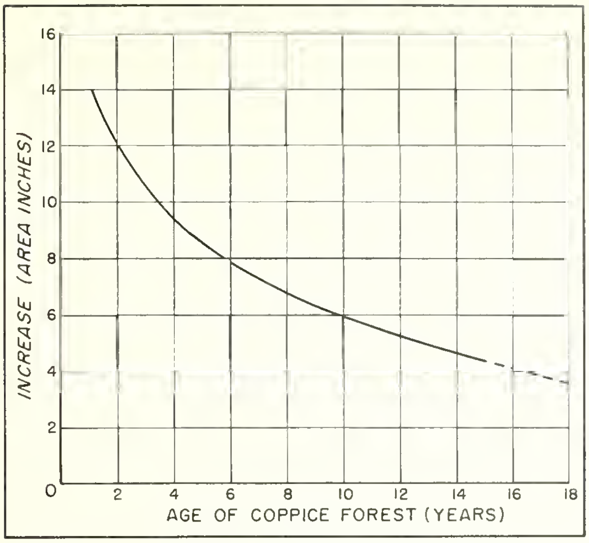
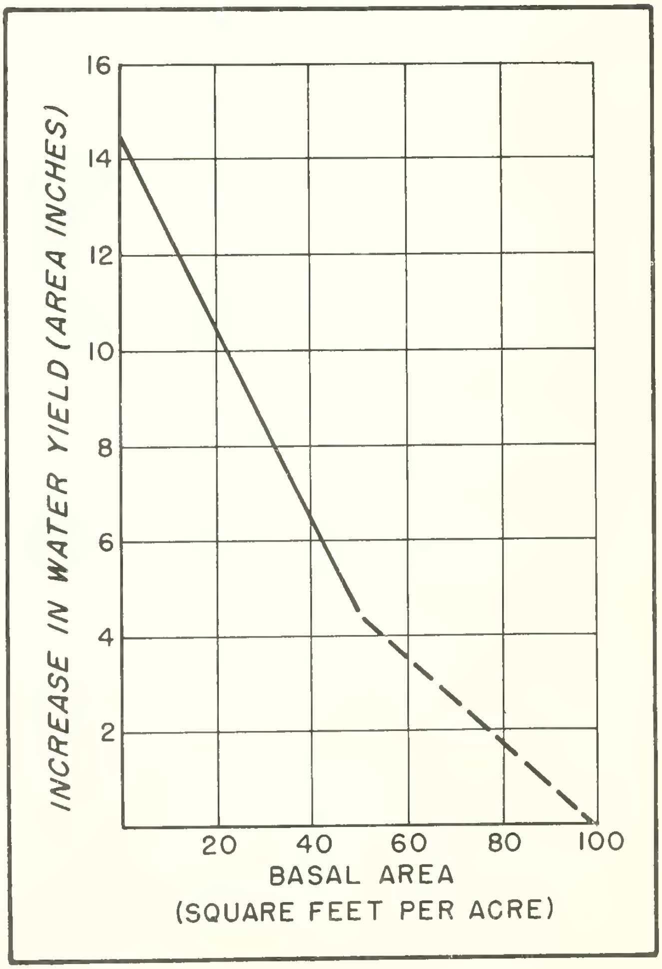


Figure 41.--Change in annual water yields after clear cutting a hardwood forest and allowing a coppice stand to grow back, Watershed 13.

the results into the future suggests that treatment effect probably will become negligible after the 35th year.

Originally the mountain hardwood stands on this particular watershed had an average basal area of about 100 square feet per acre. Cutting reduced the basal area to zero, but after 14 years of natural regrowth it was back to approximately 50 square feet. During these 14 years, the average annual water yields decreased at the rate of 0.2 inch per square foot of basal area, as shown in figure 42; and from the 14th year on until treatment effect theoretically becomes negligible, the indicated rate of decline is 0.1 inch per square foot. For conditions similar to those at Coweeta, this experiment illustrates that water yields can be materially increased or decreased by making substantial changes in forest cover.

Figure 42.--Water yield in relation to basal-area growth of a 15-year-old coppice forest. Watershed 13.



On Watershed 19 a dense understory of laurel and rhododendron was cut in an old-growth hardwood stand. Water yield the first year after cutting increased 2.8 area inches (adjusted for rainfall variable), as shown in figure 43. Since natural regrowth was not cut subsequently, the flow increases have declined with time, and should be back to the pretreatment level by about the 10th year. Thus, this type of cutting produces rather small, temporary increases in streamflow. Until more evidence is available, it is tentatively concluded that cutting the understory affords only limited opportunity to increase water supplies effectively, compared with cutting the hardwood overstory.

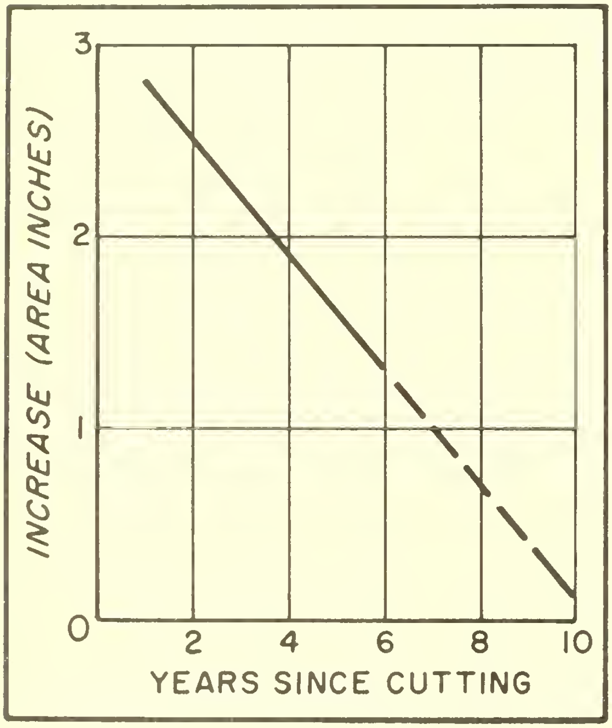


Figure 43.--Annual increases in streamflow after cutting laurel-rhododendron understory on Watershed 19 (estimated after the sixth year).

Gullied Piedmont Lands Can be Quickly Stabilized

Usually, one of the first requirements in watershed management is to rehabilitate eroded, gullied lands. In the Southeast, many areas can be rather quickly reclaimed with simple measures, while others require considerable expense and effort. Shown in figure 44 are before-and-after views of a gullied old-field on the Calhoun Experimental Forest, near Union, S.C. First the network of gullies was partly levelled with a bulldozer so that vegetation could get a foothold. Then the area was seeded to sericea lespedeza and crotalaria, and was fertilized and lightly mulched with pine straw. Already stabilized effectively, this tract will soon be planted to loblolly pine to afford a more permanent cover.

Figure 44.--Gullied old-field before treatment, and the first year after treatment.

Some Applications of Danger Measurements

One might suppose because there are more acres protected, more money available, more prevention publicity, more fire-fighting equipment, and more of the many other things that go with the never-ending battle against wildfire, that we are getting on top of the fire job in the Southeast. Perhaps we are, but if so it is not descernible from the records of total numbers of fires and acres burned.

Such records, however, do not tell the whole story. Extremely severe burning conditions have been experienced in the Southern Coastal Plain for the past several years. There are more woods workers and woods users and, therefore, more potential fire setters. Perhaps the more severe conditions and higher risk have more than offset increased efficiency of protection agencies. But how is it possible to balance the plus against the minus elements and to obtain some reasonable measure of effectiveness of fire control activities?

A partial answer is to develop methods for taking out the effect of weather, because weather more than any other factor influences fire occurrence and behavior. This has been done successfully for the Northeast, where the system of danger measurement developed by the Station has been in use for many years. Briefly, a number of factors that influence burning conditions, measured at fire danger stations, are integrated by a danger meter on a numerical scale called the Burning Index. On an easy day, only a few units of Index are indicated. When conditions are extreme, the Index may go as high as 120 or 130 units. As the Burning Index increases, the number of fires and rate of spread also increase. Thus, by summing the daily Indexes it is possible to compare the severity of any season or year with any other season or year for which good records are available.

The foregoing is illustrated in figure 45, in which 12 individual years are compared percentage-wise with a 10-year average. The figures are from a district of about a million acres in a northeastern state. For this area the easy and severe years are identifiable at a glance: 1952, 1953, and 1954 were the severest on record.

A more meaningful comparison, however, is obtained for the same district when yearly Burning Indexes are plotted against numbers of fires as in figure 46. The plot of numbers of fires shows no obvious trend. From this one might conclude that little, if any, progress has been made in preventing fires during the 12-year period. But from the plot of Burning Indexes it is clear that the trend is upward, particularly for the last three years of the period. Now, when occurrence rate is plotted, i.e., the number of fires

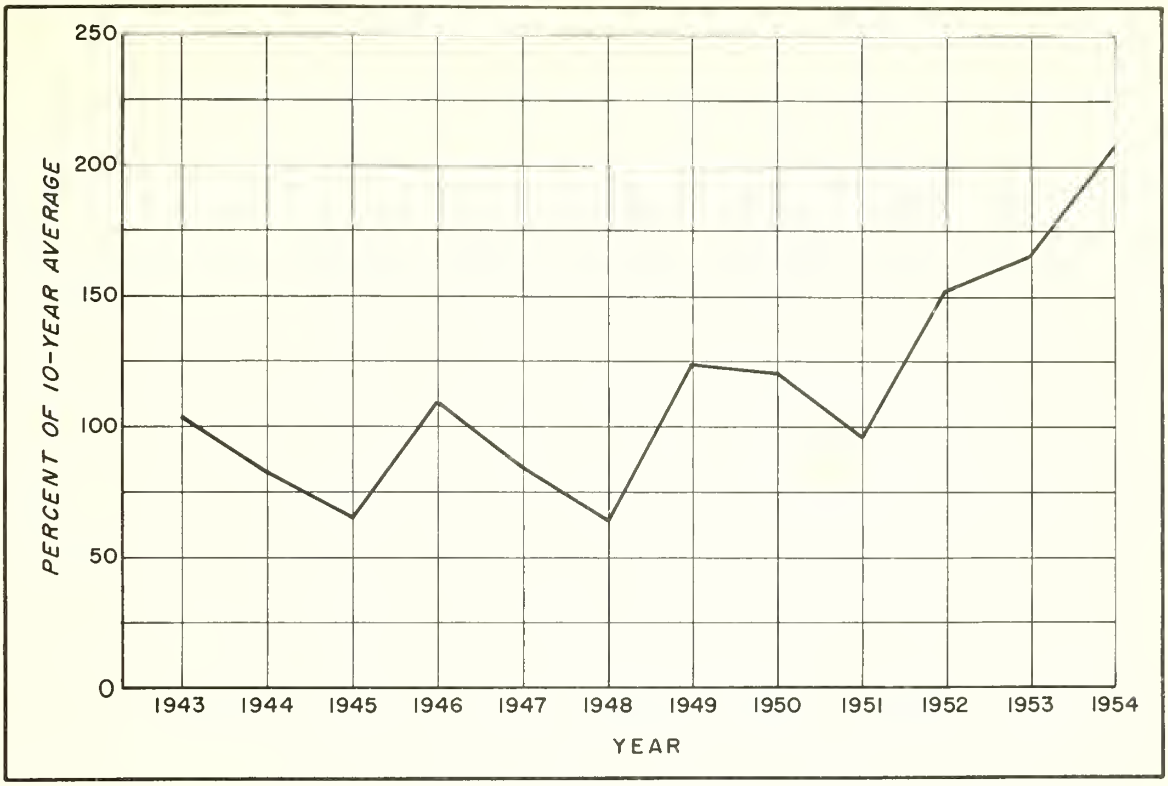


Figure 45.--Total Burning Index by years in percent of 10-year average, 1943-1952. (Data supplied by J. J. Keetch)

per thousand units of Burning Index (lower part of fig. 46), the downward trend is unmistakable. There can be only one explanation: decided progress in fire prevention has been made. We know this to be a fact because the number of potential fire starters in the area has greatly increased.

The uses of such danger measurements illustrate only two of the applications that can be made when good records over a period of years are available. They emphasize the desirability of careful location, operation, and supervision of danger stations.

Drought Index

The recent unprecedented succession of dry years and the accompanying extremely severe fires in the Southern Coastal Plain have brought sharp attention to the need for a measure of the degree of drought. Much difficulty in controlling fires was also experienced in some sections of the Northeast in 1954 because of drought conditions. Fire suppression becomes particularly difficult when soil moisture is depleted. Swamps and bays cannot be used as natural barriers, buried material will burn under fire lines, and mopup is generally a prolonged and costly operation.

The Build-up Index on our present danger meters reflects the relative dryness or wetness of the upper 3 or 4 inches of fuel but not of the lower fuel layers or the soil profile. The development of a Drought Index--an extension or prolongation of the Build-up Index--will therefore be a major item of research during the coming year.

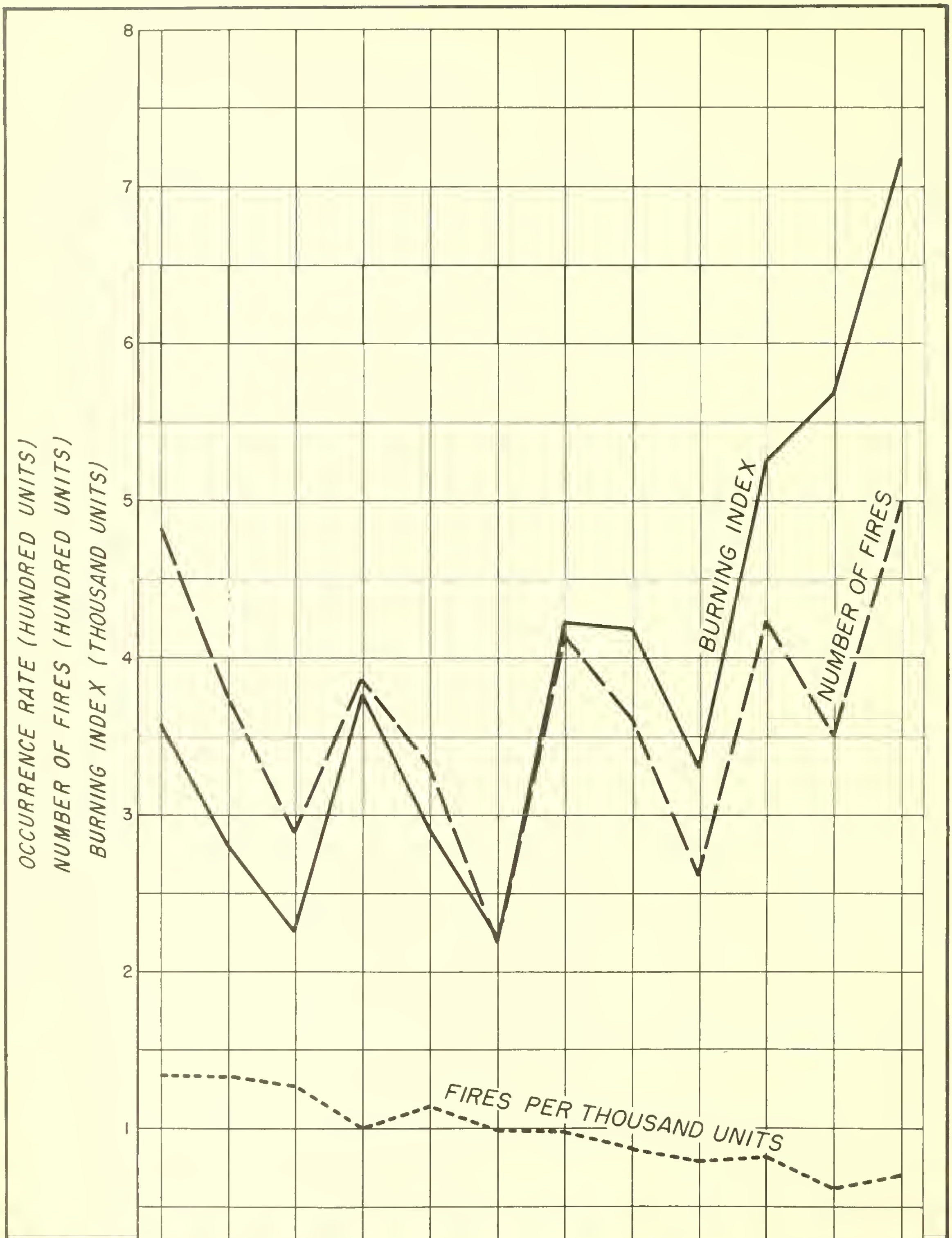


Figure 46.--Relation of fire occurrence to Burning Index during a 12-year period. (Data supplied by J. J. Keetch)

Some climatologists believe that the march of soil moisture can be determined with satisfactory results through the use of the two factors, mean temperature and precipitation. They reason that water is lost from the soil primarily through evapotranspiration, the rate of which is determined principally by mean temperature. Type of vegetation, humidity, interception, type of soil surface, runoff, amount and duration of precipitation, depth of zone from which roots draw moisture, and amount of water in the soil, among other variables, are recognized as influencing the rate of evapotranspiration. But there is considerable difference of opinion as to their relative significance. Some workers think they are of second-order importance.

Enough exploratory work was done during the year to indicate that the use of two variables, potential evapotranspiration and rainfall, is a very promising approach toward a Drought Index. The Division of Fire Research is now at work on such an index, which will later be tested.

FOREST UTILIZATION SERVICE

An expanded program of research in hardwood utilization got under way at the Athens-Macon Research Center this year, and now there are three utilization specialists working full time on charcoal manufacture, wood preservation treatment, development of hardwood paneling from defective hardwoods, and seasoning studies. A cooperative program with the University of Georgia, N. C. State College, Duke University, and Clemson College has involved fundamental and applied research in the fields of wood quality, quality control, log grading and sawmilling, seasoning, marketing methods, and other studies. The Division has supplied on-the-ground help involving seasoning, manufacturing, gluing, and finishing to scores of wood-using plants. Short courses were held in gluing, kiln drying, and quality control. Two men were added to the Forest Utilization staff, one in Asheville and one in Georgia through a cooperative arrangement with the Georgia Forestry Commission.

Source and Quality of Lumber for the Furniture Industry

A survey was conducted on the source of lumber for North Carolina furniture plants in cooperation with the Furniture, Plywood and Veneer Council of the North Carolina Forestry Association. Thirty-eight furniture companies, representing approximately 43 percent of the furniture production in the State, supplied information on their lumber source. The survey indicated that the hundreds of furniture plants in North Carolina, which account for 17 percent of the wood furniture made in the U.S., use approximately 350 million board-feet of domestic lumber a year. Approximately 44 percent comes from North Carolina, 21 percent from South Carolina and Tennessee, and 10 percent from Georgia. The remaining 25 percent comes from the Deep South and other parts of the country. Yellow-poplar exceeds all other species, making up 38 percent of the lumber used, gums 20 percent, oaks 11 percent, and yellow pine 6 percent.

An exploratory study on the amount of mismanufactured lumber received at North Carolina furniture plants was also conducted in cooperation with the Furniture, Plywood and Veneer Council to determine the cutting accuracy of small sawmill operations that supply lumber to the furniture industry. Forty-six loads of lumber, each from a different supplier, were sampled at 10 different furniture plants. Almost 10 percent of the 4/4 lumber purchased at the 10 plants did not meet the National Hardwood Lumber Rules specification for size. Thick (oversize) lumber amounted to 4.8 percent, thin (scant) lumber 1.6 percent, and uneven thickness (miscut) 2.7 percent. Howard Doyle, Council Forester, conducted most of the field work and was senior author of the publication.

Hickory Task Force

The Hickory Task Force sponsored by the Station published two reports during 1955, "Hickory for Veneer and Plywood," by John F. Lutz, and "Chemistry of Hickory," by Raymond L. Mitchell. The report on veneer and plywood gives data on how best to heat bolts and flitches for cutting, and on lathe settings, drying schedules, and veneer yields. Mitchell's report on the chemistry of hickory points out that hickory is the equivalent of other hardwoods as a source of chemical products. It also contains data on the composition of bark, nuts, and leaves. Three additional reports of the Task Force series are awaiting publication and a dozen more are being prepared. As a result of the efforts of the Hickory Task Force, ten times as many hickory cross ties are being used as formerly, much hickory flooring is now being produced, and other manufacturers are showing interest in the utilization of this valuable wood (fig. 47).

The Relation of Gelatinous Fibers to Internal Stresses in Hickory

One of the reasons why hickory is sometimes rejected is its tendency to split from internal stresses (fig. 48). During the past year a preliminary study in cooperation with Clemson College was undertaken to test the hypothesis that splitting in hickory is correlated with the presence of gelatinous fibers (tension wood). Hickory discs were collected from the butt logs of 60 trees. These were obtained from three plants in western North Carolina, western South Carolina, and eastern Tennessee. Twenty discs, 10 splitters, and 10 non-splitters, were collected at each plant. Four sample blocks were selected at random on 4 radii of each disc and the relative number of gelatinous fibers was determined from wood sections cut from these blocks (fig. 49). Analysis of variance disclosed that there is a significant difference between splitters and non-splitters in the relative number of gelatinous fibers. Work is continuing in an effort to determine how and why the presence of gelatinous fibers effects splitting quality.

Wood Seasoning

Improperly seasoned wood continues to be the source of many problems and a great deal of waste in the wood-using industries of the Southeast. In addition to providing consulting services to industries on seasoning, technicians

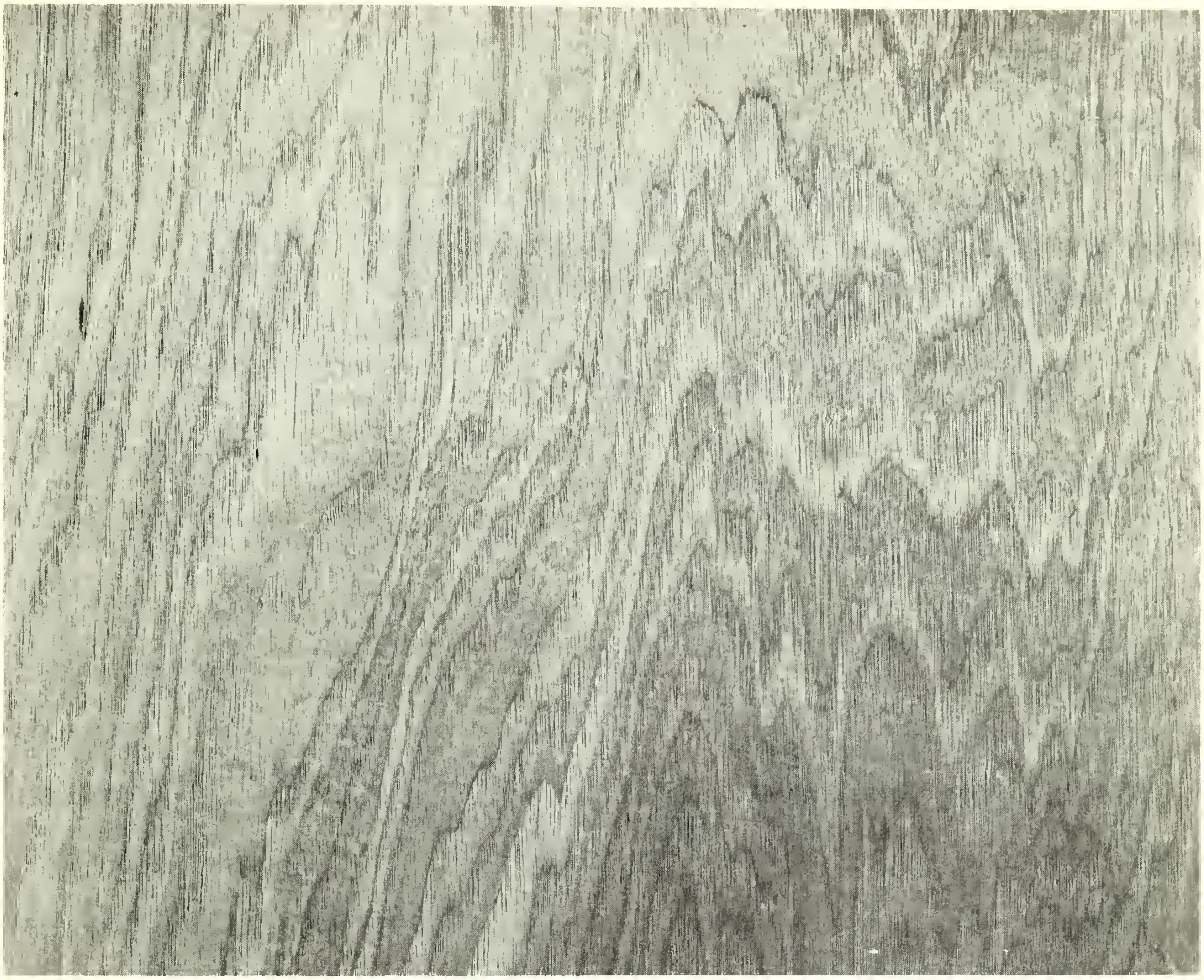


Figure 47.--Attractive furniture and plywood have been made from hickory. This is rotary-cut veneer from the heartwood of shagbark.

Figure 48.--Internal stresses often split hickory logs, causing considerable waste.

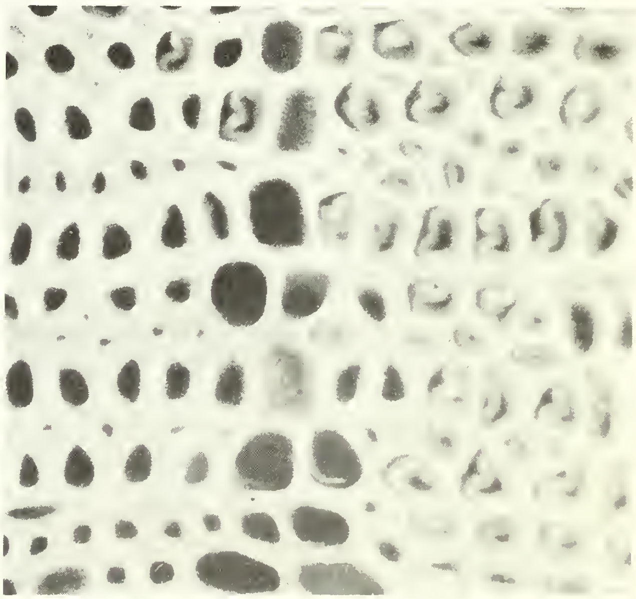


Figure 49.--Tension wood fibers shown at the right in this photomigrograph of hickory have been found to be associated with severe splitting.

conducted a kiln drying short course in cooperation with the School of Forestry at the University of Florida, and a new kiln drying association was organized for kiln operations in Georgia, Florida, and Alabama.

The value of roofing for air-seasoning yards was reported at a meeting of the Southeastern Dry Kiln Club by one of the members. An estimate of the annual losses due to seasoning defects in uncovered lumber at this plant ranged between 8 and 10 thousand dollars. At a cost of approximately \$13,600, an open shed covering 27 thousand square feet was built. The savings made it possible to write off the cost of the structure in 2 years. A similar inexpensive shed is shown in figure 50.

Charcoal

From a few small charcoal producers in the Southeast only 2 years ago, this industry has grown to 15 or more operations, and the local demand for charcoal is not yet being met during the outdoor cooking season. Studies of kiln types, production methods, charcoal yields, and marketing techniques have been an important part of the year's work (fig. 51).

The first 7-cord kiln constructed at the Whitehall Experimental Forest of the Georgia School of Forestry was operated for two runs (fig. 52). Charcoal yields and quality were high but weaknesses developed in the structure. A new kiln was designed to test double wall construction on one side, reinforced single wall construction on the other side, a new type floor, new type door arrangement, and a separately supported roof. This second research model was completed during the year and will be tested in 1956.

The opportunity for utilizing trees in the forest that are otherwise unsalable, and wood waste at plants offers an attractive opportunity where good markets for charcoal can be developed and where charcoal can be made according to the best methods (fig. 53). A cooperative charcoal marketing study is in progress with the Georgia Experiment Station and the School of Forestry of the University of Georgia.

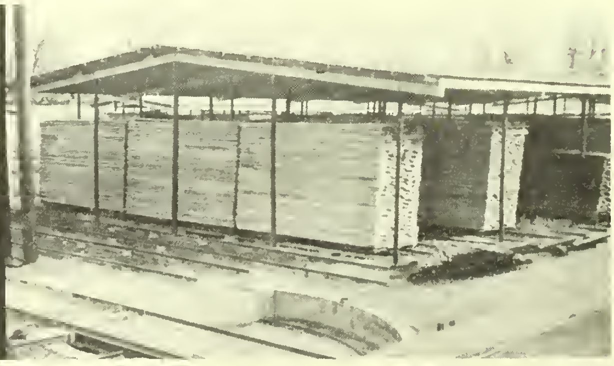


Figure 50.--An inexpensive covering over lumber seasoning yards results in warp-free lumber.

Figure 51.--Beehive metal charcoal kilns are on the market. Although much smaller than block kilns, they have been found suitable by many charcoal producers.

Figure 52.--The first experimental charcoal kiln at Athens, Ga., produced a large yield of high grade charcoal but developed structural weaknesses. An improved model is now under test.

Figure 53.--A cord of low grade hardwoods at a cost of about $10 will produce about 900 pounds of charcoal wholesaling at about $18.

The Use of Wood in Construction

Wood continues to be a most versatile building material (fig. 54).

When Hurricane Ione struck the North Carolina coast in September 1955, an engineer from the Forest Products Laboratory joined a Forest Utilization Service technician and, with special authorization from the State Head of Civil Defense, made a study of types of damage. Areas studied were at New Bern, Atlantic Beach, Morehead City, and Pamlico Beach.

Hurricane Ione produced a combination of water and wind damage that in many cases could not be separated. After more than 50 damaged homes had been examined, however, a rough pattern took shape:

Foundations.--Creosoted pilings made the best foundations in beach areas where water damage and wave action occurred. Poured concrete slabs with reinforcement stood up next best, followed by brick. Concrete and cinder block foundations were weakest, and disintegrated under minor wave action.

Tie between foundation and structure.--In most houses observed there was no tie between the foundation and sills of the structure and many houses

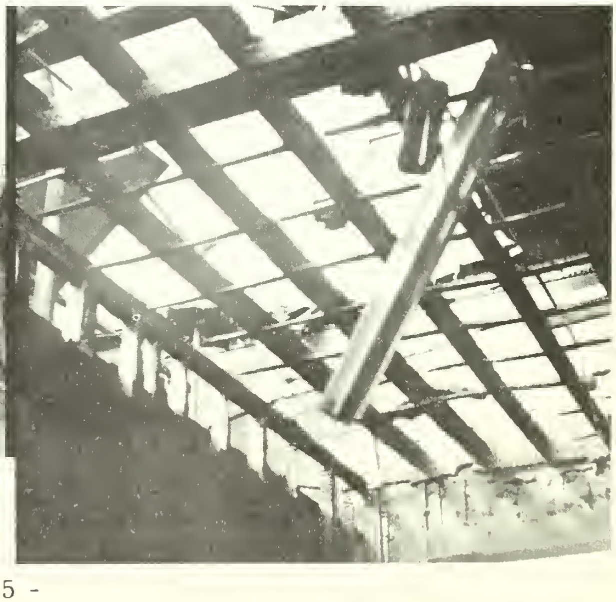


Figure 54.--A supposedly fire-proof structure gutted by fire at Asheville, N. C. Wood members were charred but supported their load, while steel beams were twisted out of shape.

were floated or blown off their foundations. Houses tied to their foundations had a better chance of surviving the hurricane (fig. 55).

House siding.--Diagonal wood sheathing covered with horizontal wood siding withstood the hurricane better than other materials. Wood shingles as siding stood up well, but asbestos shingles broke and were blown off. Brick veneer would not stand wave action, and fiberboard siding almost completely disintegrated (figures 56 and 57).

Roofing.--Wood shingles were seldom damaged by the hurricane (fig. 58), but composition asphalt shingles were blown off most roofs examined.

Grading Forest Products

As one phase of an extended program to develop a grading system for hardwood veneer logs, a cooperative study was completed at the School of Forestry, N. C. State College (fig. 59). Using a previously developed sampling technique, data on veneer yields were obtained from 189 bolts representing 4 species. The effect of bolt length and diameter upon yield of clear veneer was analyzed for 86 bolts of sweetgum. Bolt length was found to be an important factor on the yield of clear veneer. The study also showed that the yield of clear veneer was higher on a percentage basis for small diameter logs than for large ones.

Furniture Production Techniques

With the quality of available lumber becoming poorer, products manufacturers are finding it necessary to use lower grade lumber. Furniture corestock is a product in which knotty lumber can be used if the knots are cut out and replaced by clear wood patches (fig. 60). Sometimes, however, these patches "print through" the veneer surfaces and show as a blemish on the furniture. A cooperative study with N. C. State College was made to learn the cause of this print-through. It was learned that excessive pressure used to glue in the patches caused a compression of wood in the patch, which subsequently caused a print-through. A second cause of print-through was the method of sanding the panels after patching. Hand sanding operations result in print-through, whereas drum sanding minimizes it.

Preservative Treatment of Hardwood Fence Posts

The double-diffusion method of preservative treatment developed at the Forest Products Laboratory has shown excellent results over a 15-year period with pine. Not much is known about the use of this method with various species of hardwoods. At the Athens-Macon Research Center, 100 posts each of hickory, red and white oak, yellow-poplar, and red gum were treated by double-diffusion, using the full immersion method. Zinc sulphate was used as the first bath and sodium chromate as the second. Four treating schedules were investigated: 1 day soaking in each solution, 2 days in each solution, 3 days in each solution, and a hot and cold bath treatment in which the posts were soaked for 12 hours in a solution of zinc sulphate at 200°F., and then

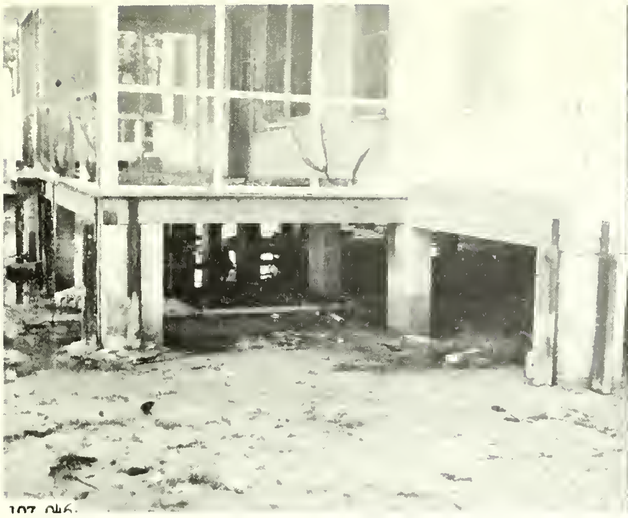


Figure 55.--This house was tied to its foundation with railroad irons. It withstood the hurricane although many nearby houses were destroyed.

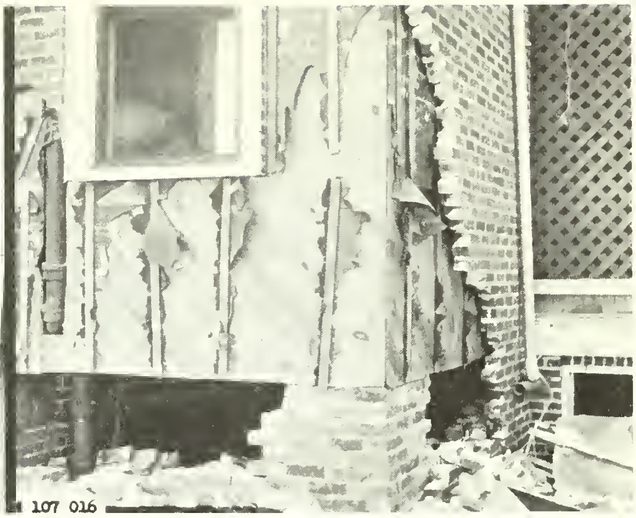


Figure 56.--Brick foundations stood up fairly well but brick veneer siding suffered damage.

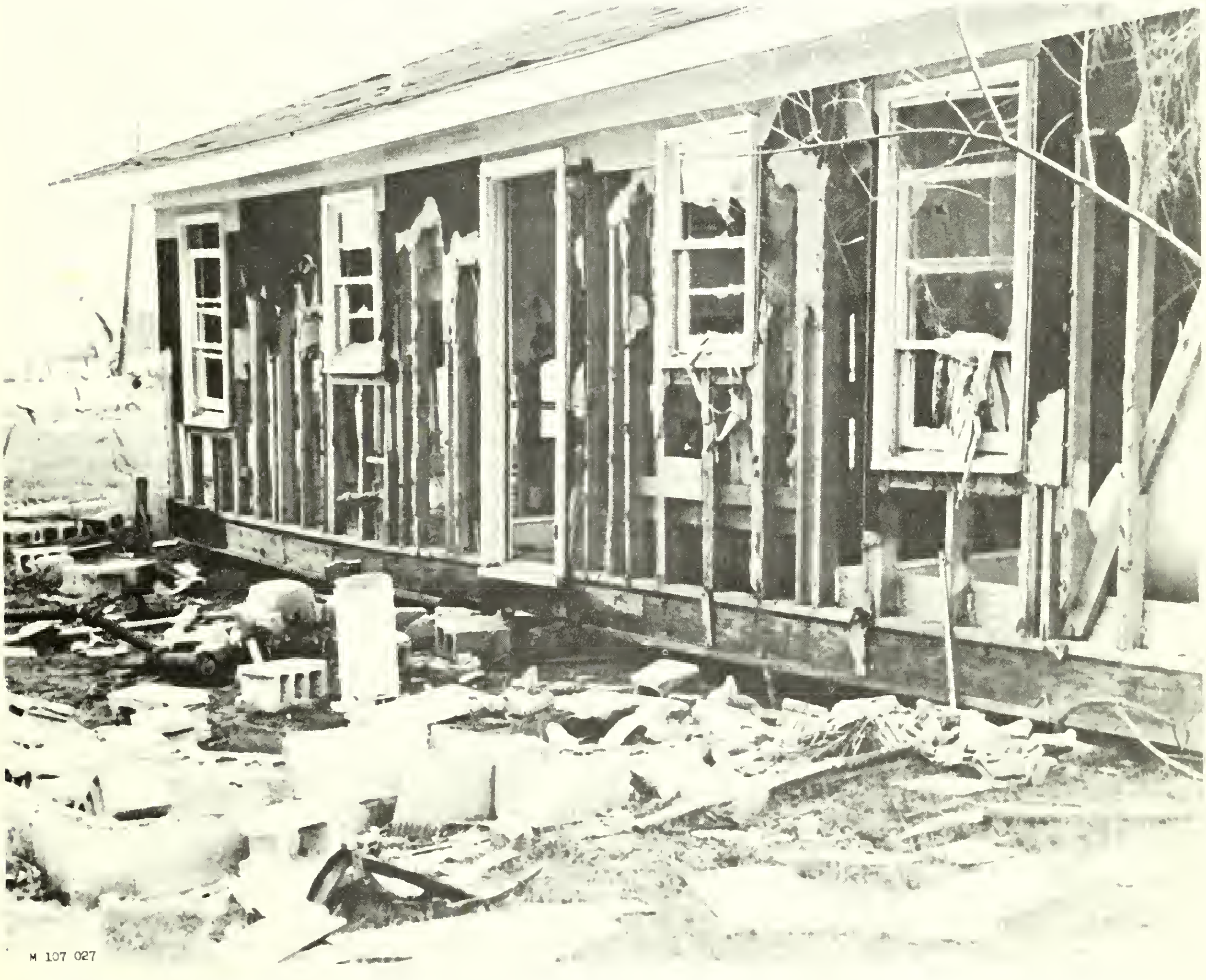


Figure 57.--Fiberboard siding and concrete block foundations were no match for Hurricane Ione, although the well built wood framework remained in relatively good condition.

Figure 58.--Asphalt shingles on the left, wood shingles on the right.

12 hours in a cold bath of sodium chromate. Some pine posts were also treated for comparative purposes. Analysis of preservative retention is now being made at the Forest Products Laboratory from sample posts, and other posts have been installed in exposure tests on the Whitehall Experimental Forest at Athens (fig. 61).

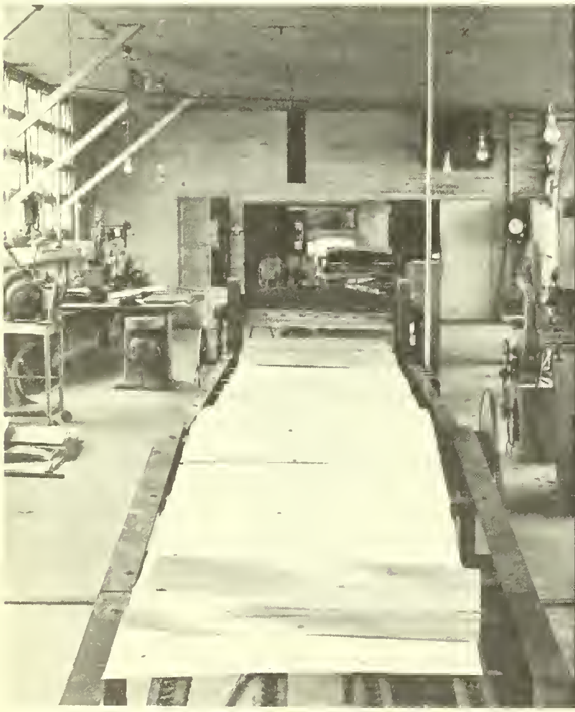


Figure 59.--Cooperative studies with N. C. State College contributed information to the development of grades for hardwood veneer bolts. (Photo by N. C. State College.)

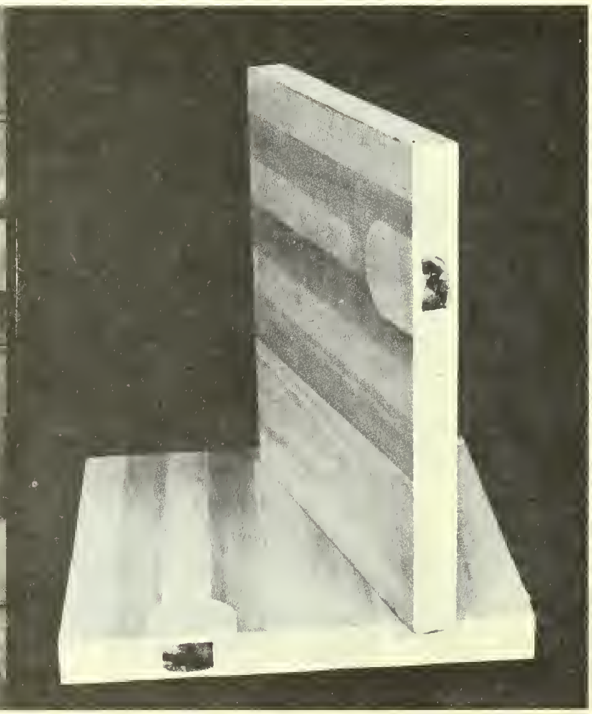


Figure 60.--A corestock panel cut in half to reveal the defect under the patch. (Photo by N. C. State College.)

The Utilization of Wood Residue

A study recently completed in North Carolina shows that about 44 percent of the residue accumulating in the forests, at the sawmills, and in the manufacturing plants is unused and available at a relatively low cost. About 40 percent of the residue used is burned for fuel that brings a low price or none at all.

Several pulp mills are interested in the volume of wood residue available and are beginning to buy chips from sawmills, and some are putting in their own equipment at concentration yards to convert slabs to chips that are shipped to the pulp mill.

A survey of the use of wood residue used for agriculture made by Professor Grant of the Georgia School of Forestry in the Georgia Piedmont revealed a strong demand for wood shavings to be used as litter in poultry houses; they bring from 6 to 8 dollars per ton.

More than ten chipboard plants are either operating or under construction in the Southeast, whereas a year ago there were only two. These plants help to convert waste into useful products such as corestock for furniture and plywood, insulating board, and construction board.

Figure 61.--Service test area for hardwood fence posts treated by the double diffusion method, Athens, Georgia.

RANGE MANAGEMENT RESEARCH

Major accomplishments during the year in the Station's range research included: (1) bringing certain phases of the south Georgia work on wiregrass-pine ranges to a reportable status, (2) starting new research in south Florida, and (3) summarizing the findings from the remaining studies on management of Tidewater cane range in eastern North Carolina.

The findings from the cooperative work in south Georgia supply much-needed guides for better use and management of forest range. A grazing capacity study completed and reported in 1955 affords some useful criteria for judging carrying capacity of wiregrass ranges, thereby enabling increased cattle production through proper use of available forage. Moreover, the results from a continuing cattle management study of native forage and improved pasture demonstrate that progress is being made in south Georgia towards getting increased livestock production from forest range.

One of the year's accomplishments was completion of a project analysis for range management research in south Florida. Under way for two years and scheduled for issuance as a Station paper in 1956, the analysis outlines principal range problems and suggests research needs and priorities. By the end of 1955, arrangements were well along for a comprehensive grazing-capacity study on the lands of a cooperator. Good progress was also made, in cooperation with North Carolina State College, in bringing unreported studies, representing some 14 years of investigations of native cane range, to a conclusion.

Grazing Capacity of South Georgia Forest Ranges

For many years cattlemen have depended on observation and experience in evaluating capacity of forest range; and more often than not their ranges have been overstocked. In cooperative studies with the Agricultural Research Service and the Georgia Coastal Plain Experiment Station on the Alapaha Experimental Range, rates of stocking have had to be scaled down repeatedly to avoid overgrazing. However, until completion of the grazing-capacity study last year it was not known just how much wiregrass-pine range is needed for best cattle performance.

Results of this study show that animal gains were related to available forage and degree of use (table 12 and fig. 62). Maximum weight gain of steers was associated with ample available forage and light utilization, and the gains were least when rate of stocking and degree of forage utilization was greatest. Based on a grass yield of 1060 pounds per acre, the study suggests that approximately 9 acres of forest range are needed to produce top gains for a 500-pound steer from March to January. For a mature animal about 15 acres would be needed.

Table 12.--Body weight changes of steers, and forage utilization under three rates of stocking, wiregrass-pine ranges 1/

Burned wiregrass range		Forage removed by grazing	Initial steer weight Mar. 15	Weight change per steer	
Actual	Adjusted to open conditions			Mar. 15-Oct. 25	Oct. 26-Jan. 17
Acres		Percent	Pounds		
LIGHTLY STOCKED RANGES					
18.1	14.5	29	465	155	-49
14.2	8.5	32	457	167	-47
MODERATELY STOCKED RANGES					
8.5	6.9	38	481	118	-55
6.8	5.3	48	479	117	-42
6.4	4.4	46	495	108	-48
HEAVILY STOCKED RANGE					
4.4	3.0	65	480	76	-60

1/ Average for 1950, 1951, 1953, and 1954. Steers were removed from range on October 26, 1954.

Figure 62.--Fifteen acres of forest range such as this provided grazing for each 500-pound steer from March to January. Gains were 145 pounds per animal.

The findings also emphasize need to make adjustments for decrease in grass yields caused by tree overstory and shrub cover. The following regression formula affords a guide for making these adjustments: Y(estimated grass yield) = 1060 - 15X(overhead tree canopy in percent) - $13X_2$(shrub cover percent). For example, 555 pounds of grass would be the estimated grass yield on a forest range where tree canopy was 25 percent and shrub cover 10 percent. The approximate amount of forest range for maximum gains (500-pound steer) would be 17 acres. Thus, although grazing capacity varies through a timber rotation, the formula affords a practical means of making periodic adjustments to assure proper stocking.

Better Cattle Management Practices Increase Beef Production on Wiregrass-Pine Ranges

The cooperative Alapaha studies in south Georgia, under way since 1942, point up some of the advantages of good cattle management practices on forest range.

A main purpose of these investigations was to investigate possibilities for improving range cattle production. Four herd-management systems were tested during the first 5 years, 1942-1947. One of the more practical systems was as follows: Grade Hereford and native cows bred to Hereford bulls were provided 3-7 acres of burned wiregrass range per cow from March 16 to January 31. Each cow was fed 1 pound of cottonseed meal per day from October 16 to January 31. On February 1, cows were taken off range and put in the feedlot. They were fed 20-25 pounds of chopped sugarcane plus 2 pounds of cottonseed meal per head daily until March 15, when they were again turned on range. Under this kind of management, cow death losses were nil but calving percentage and weaned weight of calf at 8 months was low (table 13).

Table 13.--Calf crop and weaned weight of calves from cattle grazing native wiregrass range

Testing period	Cows weaning calves	Calf weight at weaning
Years	Percent	Pounds
1942-1947	57	273
1948-1952	55	295
1953-1955 [1/]	76	418

1/ Study still in progress.

During the next 5 years (1948-1952) about the same schedule was maintained, but for a different group of grade Hereford cows. Other changes involved use of Brahman bulls and increasing the acreage of burned range to 7-10 acres per cow. Calving percentage was about the same as in the previous period but the weaned weight of calves was increased nearly 20 pounds on the average.

Beginning in 1953, several important changes were made. Included as test animals, in addition to the grade Hereford cows, were some crossbred cows--half Brahman and half grade Hereford. These were bred to Shorthorn bulls. The burned range was increased to 12-15 acres per cow. Instead of leaving cows on the range after October, they were moved to Coastal Bermudagrass pastures which had been in hay production during the summer. For the rest of the fall and winter, until March 15, cows were either on improved permanent pasture (frosted grass and sometimes small quantities of white clover) or in the feedlot where they were fed daily 20-25 pounds of Coastal Bermudagrass hay per head.

Cattle response to this better management has been very pronounced, although the test has been under way only 3 years, 1953-1955. Calving percentage for the 3-year period was 76 percent. Moreover, calves at weaning averaged 418 pounds, which is 120 pounds greater than for previous periods when cows grazed unsupplemented native range during spring and summer (fig. 63). The calves from crossbred cows were about 46 pounds heavier at weaning than those from grade Herefords.

These tests will continue to further evaluate the role of better management practices in getting more beef production from wiregrass-pine ranges. The results to date point up the importance of three practices: using crossbred cattle including some Brahman blood, providing adequate native wiregrass forage during spring and summer months, and employing a good feeding program in the fall and winter.

Figure 63.--These cows each had 12-15 acres of burned forest range during spring and summer. They were fed to gain slightly during fall and winter. As a result, calf weaning weights, October 15, averaged 418 pounds, 1953-1955.

Study to Integrate Cattle and Timber Production at George Walton Experimental Forest

Cattle production as practiced by most forest landowners in the coastal plain often interferes with good timber management; and there are few instances as yet of well-integrated operations to minimize these conflicts. During the past year, arrangements were made through agreement with Holt E. Walton, landowner, to demonstrate good livestock management practices on his timberlands near Cordele, Georgia. These are being managed intensively for timber production in accordance with an existing cooperative agreement which has been in force for several years. In order to utilize forage values created by thinning and other timber-cutting operations, cattle will be grazed to the extent that grazing does not interfere with timber production. Burning will not be a part of the program except as prescribed by foresters for silvicultural purposes. A continuous record of cow performance along with a cost and return account for all phases of the project will shed considerable light on the economics of grazing cattle on intensively-managed timber lands of this kind.

Rate-of-Stocking Study for South Florida Native Ranges

One of the most urgent range management needs in south Florida is knowledge of what constitutes proper stocking, i.e., how many cattle can be grazed per acre or section while maintaining the forest range in good condition and at the same time obtaining good cattle yields. Estimates of this vary widely--from 8 to 20 (or even 40) acres per cow per year. The recently completed project analysis for south Florida pointed this up as a foremost question needing immediate answer, both by progressive ranchers and by range technicians who need the information as a base upon which to program and plan other studies. Thus, a rate-of-stocking study was selected as the Station's first major range research investigation in Florida.

During 1955, a plan for this study was worked out in some detail with cooperators, ranchers and technicians, including scientists of the Florida Agricultural Experiment Station. Negotiations beginning early in 1955 led to the signing of a 10-year memorandum of understanding between the Babcock-Florida Company and the Forest Service, covering range management research work in south Florida. A 1,580-acre tract of cutover pine land, named the Caloosa Experimental Range, has been provided in Charlotte County by the Company, along with the use of approximately 82 head of cows and bulls. Miscellaneous assistance in cattle handling will be provided. Fences, corrals, wells, and other improvements have been installed by the Forest Service so that cattle can be turned into the area March 1, 1956.

Oak Wilt

Surveys of the Southern Appalachian national forests revealed only two infection spots on the George Washington, one on the Cherokee, and 14 on private lands intermingled with the holdings of the George Washington, Cherokee, Jefferson, and Monongahela. About one-fifth of the old infection spots in Arkansas and Tennessee were active in 1955, and about the same number of new centers were found while checking the old ones. Figure 64 shows the counties where oak wilt has been found in the Appalachians. Oak wilt control was practiced in 1955 by all of the Appalachian States in which the disease has been found.

Only 6 of 94 diseased trees deep girdled, or cut, bucked, and sprayed with a BHC pentachloraphenol mixture during the summer in North Carolina and Tennessee formed mats by November, and most were too dry for later mat production the next spring when infections are regarded as most likely.

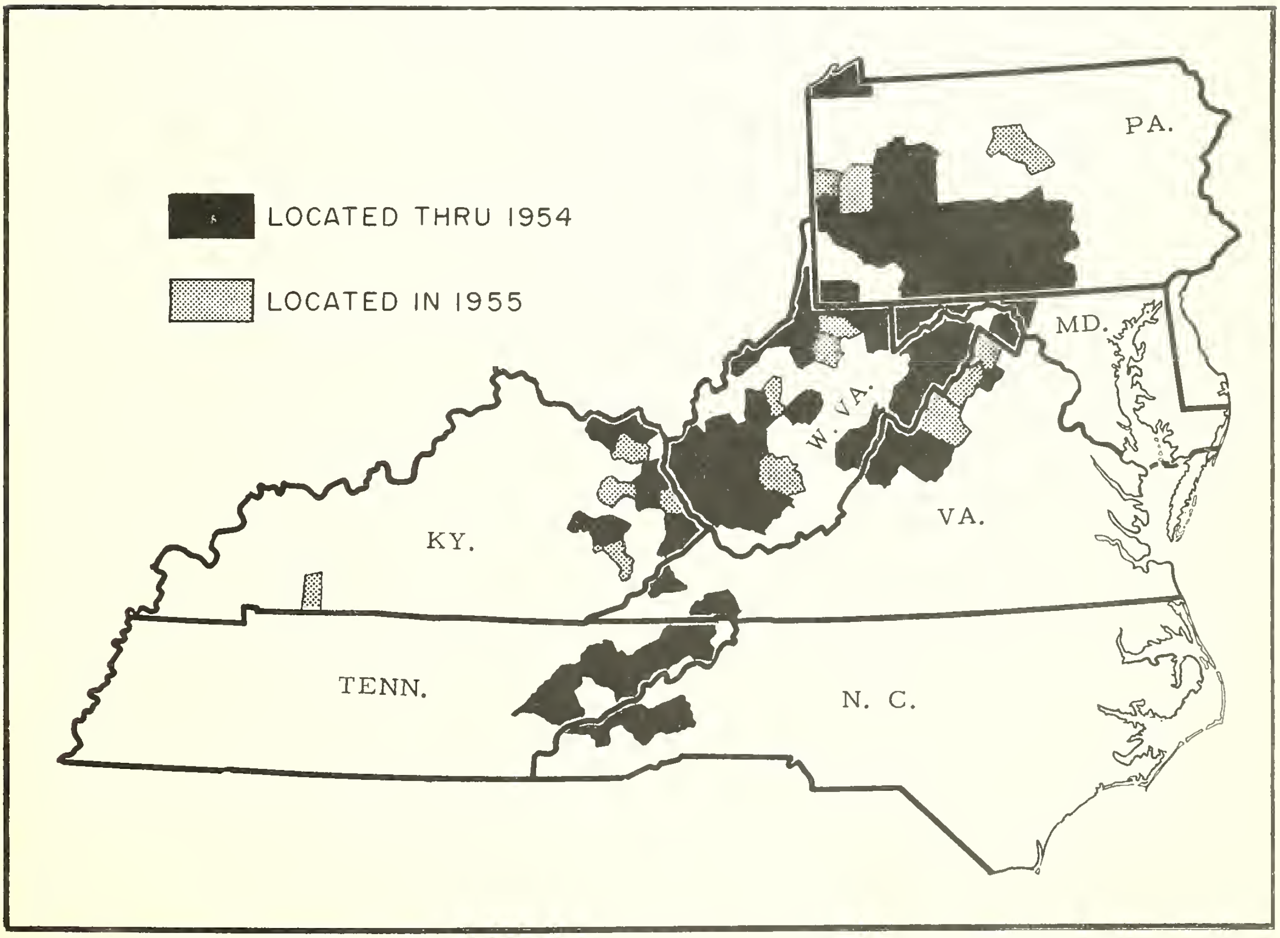


Figure 64.--Counties in Appalachian States in which oak wilt has been reported through 1955.

New infection centers in Greene County, Tennessee, in 1954 and 1955 numbered 9 and 8 respectively, with no control applied in 1954. New centers in Buncombe and Haywood Counties, North Carolina, numbered 9 and 3, with control measured applied in 1954.

When 12 fresh oak stumps were poisoned with copper sulfate, three unpoisoned white oaks next to poisoned red oaks and one red oak close to a poisoned red oak developed foliar copper symptoms, showing root grafting of white to red oak.

The oak wilt fungus stayed alive in 1-inch lumber cut from wilted trees a maximum of 16 weeks sticker-piled or 18 weeks bulk-piled, plus a log storage period of 6 weeks. The fungus was not isolated from sapwood with less than 20 percent moisture. It grew from the outer annual ring to at least 1 inch deep in the sapwood in 6 weeks after felling.

Littleleaf

Application of 1 ton of 5-10-5 fertilizer per acre plus supplemental nitrogen to at least 250 lbs. per acre continues to give high prevention and some recovery from littleleaf. More than 500 increment cores from healthy trees on a large number of fertilizer plots are being used to study shortleaf response to fertilization.

Liquid culture inoculations with the littleleaf fungus, *Phytophthora cinnamomi*, showed shortleaf pine roots to be very susceptible; loblolly, slash, and longleaf less so; Arizona cypress slightly infected; redbud even less so; and sweetgum roots not at all.

Plots in a tract from which the littleleaf trees were cut as they appeared every year for 10 years had a cumulative total of 36 percent of the trees diseased. Plots in a near-by uncut area had 50 percent diseased after 10 years.

About 3,500 seedlings were grown, representing open- and controlled-pollinated material selected for resistance to littleleaf. The first resistance progeny test was dismantled, and indicated a definite inheritance of resistance by open-pollinated progeny from selected healthy parent trees (figures 65 and 66) growing in littleleaf stands.

In addition, new selections have been made, a grafted seed orchard established, air-layering rooting technique successfully used on shortleaf, and new and better inoculation methods developed for resistance trials.

Nursery Diseases

Root rot.--Large scale fumigation at the Herty (Georgia) Nursery with methyl bromide eliminated root rot. Soil samples taken from plots at Georgia's Herty, Davisboro, and Horseshoe Bend Nurseries in areas treated with eight different fumigant chemicals were examined for content of fungi and nematodes. The effects of four fumigants on soil fungi at different depths at two

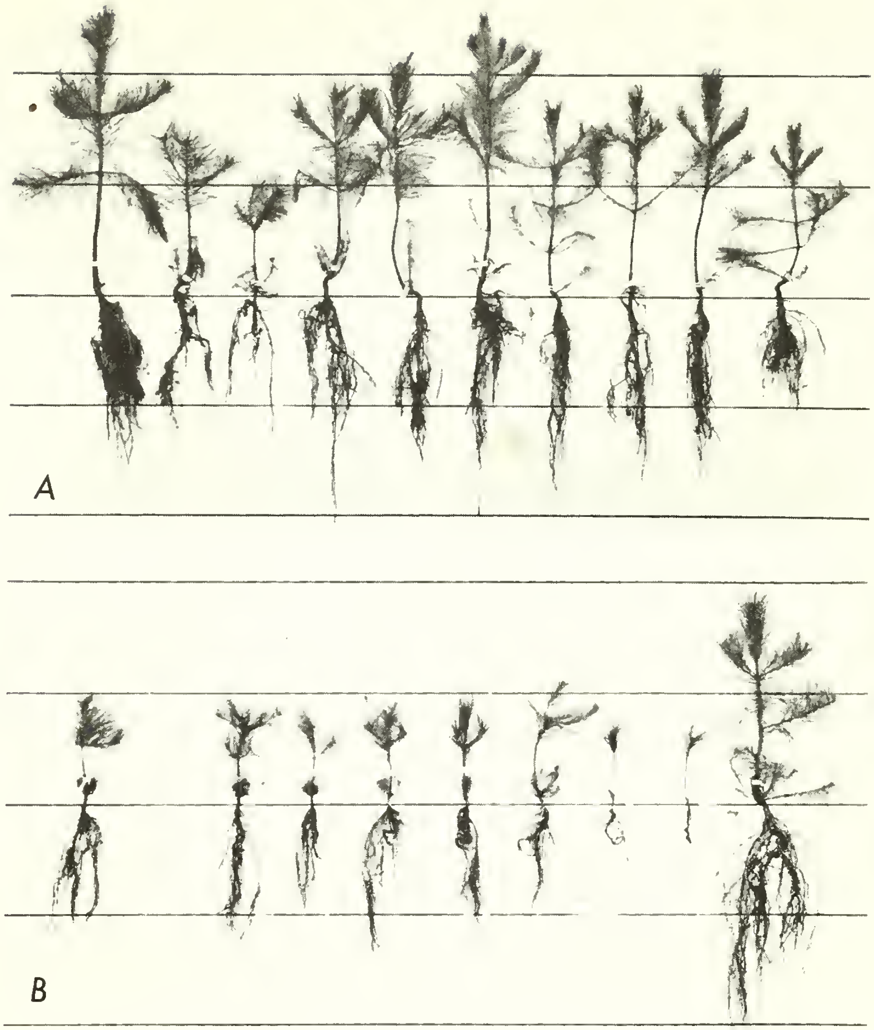


Figure 65.--Shortleaf pine seedlings from open-pollinated seed, inoculated with Phytophthora cinnamomi in their second year. A, From a healthy tree, showing apparent resistance to littleleaf. B, From a littleleaf tree.

Georgia nurseries, as studied in cooperation with J. H. Miller of the University of Georgia, are shown in table 14.

Table 14.--Effect of fumigants on eliminating soil fungi at different soil depths

Depth (inches)	Nursery			Fumigant			
	Herty	Davis-boro	Both	Methyl bromide	EDB	Vapam	Crag
	Percent fungus colonies obtained			Colonies obtained after fumigation, as percent of check			
2	25	13	38	59	122	27	58
6	24	12	36	82	97	28	83
12	10	5	15	53	58	67	41
24	9	2	11	131	137	167	38

Figure 66.--Littleleaf resistance progeny test of shortleaf pine. Root systems of A, susceptible seedling, and B, resistant seedling.

Vapam was the most effective fungicide. One percent of the colonies were phycomycetes, 2 percent were ascomycetes, and 97 percent fungi imperfecti. The most likely pathogens encountered were Neocosmospora, Thielavia, Brachycladium, Curvularia, Fusarium, Phoma, and Sclerotium. Of the nematodes found in these soils, the most likely pathogens were Heterodera, Pratylenchus, and Hemicycliophora. Further work on both nematodes and fungi is contemplated.

Studies in cooperation with Miller of Georgia and Eldon Cairns of Alabama Polytechnic Institute have been initiated in an attempt to find which of the many organisms present are responsible for root rot. A new nematode species related to the parasitic genus Heterodera has been found abundantly on seedlings from two Florida nurseries which show root rot symptoms. There are indications that the same species may be present at Albany, Georgia. The fungus Cylindrocladium scoparium was associated with seedling disease of white pine at North Carolina's Holmes Nursery.

Irrigation.--Tests of three methods of determining moisture content of soil show that all three instruments, a tensiometer, a Boyoucos meter, and an Aquaprobe, are sufficiently accurate for commercial use in nursery irrigation.

Rotation.--A long term experiment was designed to determine the effect of eight different cover crops used in rotation with pine seedlings, as compared to continuous cropping to pines. The first summer cover crop was grown and winter cover crops have been established.

Damping off.--An outbreak of damping-off in a poorly drained section of the Georgia Hightower Nursery necessitated establishment of tests with fungicidal chemicals. Under the severe conditions at this nursery, no treatments were adequate for eliminating the trouble but Captan and Thiram, used as a drench, were the most promising materials.

Seedbed density.--A study of seedbed densities installed at four Georgia nurseries showed that growing seedlings at 40 per square foot was economically feasible. The number of plantable seedlings increased proportionately with each increase in density to the maximum tested, which was 40.

Fomes annosus Root Rot

This potentially important disease has appeared in white and slash pine plantations in the Southeast. A survey was made for it in 17 white pine plantings over 20 years old, and 26 slash pine plantings over 15 years old. Eleven percent of the 850 white pines examined disclosed *Fomes annosus* decay (fig. 67), with 7 of the 11 percent occurring in two plantations. Four slash pine plantations in one forest in South Carolina showed abundant evidence of rot.

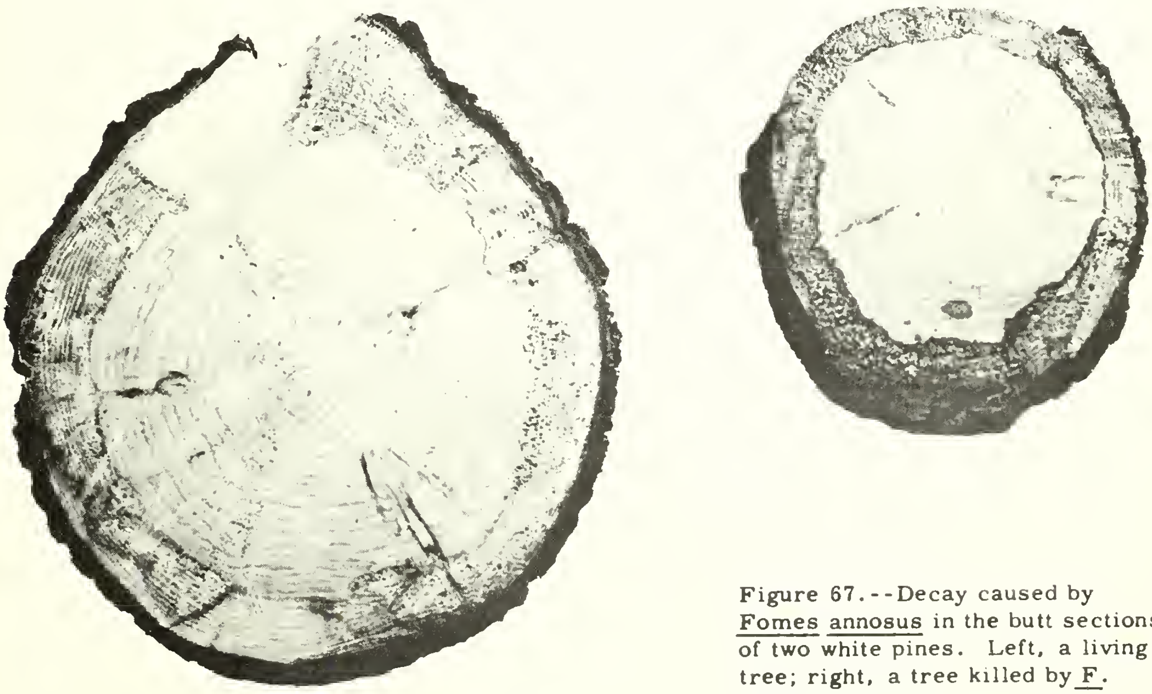


Figure 67.--Decay caused by *Fomes annosus* in the butt sections of two white pines. Left, a living tree; right, a tree killed by *F. annosus* root rot.

Defects in Piedmont Hardwoods

An extensive study of Piedmont hardwood defects is under way. A working plan has been prepared and over 400 trees studied in preliminary surveys. The most prevalent defect noted was epicormic branching. This study will evaluate both internal and external defects and their role in the problem of better hardwood utilization.

Virginia Pine Rust

A stem rust of Virginia pine was described in 1952 as *Peridermium appalachianum* n. sp. Since then, the foliage of the shrub *Buckleya distichophylla* has been found heavily infected with a Cronartium near rust-cankered trees. Inoculation of Buckleya foliage with aeciospores of *P. appalachianum* from pine produced 74 uredinia, and thus, although inoculation results are scant, it appears that Buckleya is the alternate host of the rust and the fungus would take the name *Cronartium appalachianum*. The rust has been found in 16 counties in North Carolina, Tennessee, Virginia, and West Virginia.

Pitch Streak

This condition, which has caused important tree mortality in some turpentined south Georgia stands, involves the death of bark with accompanying gum flow and pitch soak of wood for distances to 45 feet up the trunk of slash pine, and to a lesser extent longleaf. A new survey showed 8 percent of 1,700 trees in 34 south Georgia stands to be affected. Only turpentined trees with some degree of dry-face or badly injured trees showed pitch streak. In extreme cases it leads to bronzing of the foliage and to death. Pitch streak, as now described, may well be an exaggerated manifestation of a similar condition described by others as early as 1932, and may be associated with drought and other factors that lead to dry-face. Its cause and potential importance are yet to be determined.

Pitch Canker

These plots were established in 1948 to study the spread of pitch canker. Two of these plots were established at Bent Creek and the other near Clemson, South Carolina. On a 1.4-acre plot at Bent Creek, 11 new cankers were found this year. In 1948 this plot had 37 cankers and now has 148. The other Bent Creek plot is 3.4 acres in area and had 45 cankers in 1948. The number of cankers on this plot has increased to 85. The 1.5-acre plot at Clemson, South Carolina, originally had one canker, and no new cankers have been found since. The plot showing the greatest increase has the greatest number of small trees. Since the Bent Creek plots were established, 54 trees have been killed and several more are badly deformed.

Decay in Wooden Ships

In cooperation with the Bureau of Ships, U. S. Navy, an examination was made for decay in inactive wooden ships kept under dehumidification in Florida. The wood moisture content of hull members above waterline was generally too low for the development of decay. Moisture-meter readings of much of the wood below waterline was high, but this was partly caused by salt content of the wood. The interiors had not noticeably deteriorated since the experimental dehumidification started in June 1952. Though parts of the superstructures of the ships were given superficial treatments before the experiment started, decay in them has continued, especially where rainwater accumulated or where drying was prevented by joints or fittings. Borings made from the outside near waterline showed considerably decay in hull plant but less in the frames. Recommendations for changes in construction and in other features contributing to a high decay hazard have been prepared and will be submitted to the Bureau of Ships.

FOREST INSECT RESEARCH

During the year, the insect research and survey programs have been expanded. Four men are now assigned to insect research in the region, and research is in progress on the most critical problems. Significant results have been obtained regarding the control of southern pine beetle, pales weevil, tip moth and the black turpentine beetle. There has been great activity in the survey-control program: Interest in detection programs has been stimulated in a number of states, forest pest committees have been formed, and more are under consideration, bark beetle surveys have been made in all of the southeastern states, and technical assistance has been rendered on a number of control projects.

Southern Pine Beetle

This was the third consecutive year of intensive surveys and control of the southern pine beetle in the Southern Appalachians. Field investigation of reports during 1955 showed that this insect was also present in northern Georgia-South Carolina and the Piedmont of North Carolina-Virginia, probably in 1954 as well as 1955. Organized control efforts and natural beetle mortality caused a steady general decline in the occurrence of attacked trees since spring. Even though the beetle population has declined to endemic levels in many areas, serious concentrations of beetle-infested trees still remain and are currently being controlled.

In 1955 nearly 75,000 pines were felled and sprayed (fig. 68) with a $\frac{1}{4}$ percent fuel oil solution of gamma BHC (benzene hexachloride) on the North Carolina and Cherokee National Forests. An additional 15,000 trees were treated on the Great Smoky Mountains National Park, Cherokee Indian

Figure 68.--Spraying a felled tree infested by southern pine beetle. The spray is 0.25 percent gamma benzene hexachloride in fuel oil.

Reservation, and Blue Ridge Parkway. Because many infested stands were inaccessible, unmerchantable in size, and lacked pulpwood markets, only about 30 percent of the total volume killed this year was actually salvaged.

Results of various tests show that $\frac{1}{4}$ and $\frac{1}{2}$ percent gamma BHC oil solutions are the most effective and cheapest material for control of the southern pine beetle. BHC oil solutions were as effective in killing, by contact, the brood under the bark as any other insecticides; in addition, remaining broods received a lethal dose when boring out through the bark or while walking over the residual insecticide deposit in the outer bark layers. Other insecticides did not kill emerging beetles.

The use of water emulsions would eliminate a great deal of "packing" oil into inaccessible areas where water in streams is available. Our tests have shown that $\frac{1}{2}$ percent gamma BHC emulsion is about 50 percent effective in controlling the beetles under the bark. In addition, up to 4 weeks after application, it is effective in controlling about one-half of the beetles emerging and walking over the bark surface (fig. 69) prior to flight. Thus, the relatively low cumulative mortality and short period of residual effectiveness will greatly limit, if not prohibit, the use of BHC water emulsion on control projects.

Figure 69.--Testing the residual control effectiveness of 0.5 percent water emulsion of BHC on the southern pine beetle. Beetles were permitted to crawl on bark for various intervals up to 4 minutes. Logs had been previously sprayed and allowed to weather for 2, 4, and 8 weeks.

Ips Engraver Beetles

Figures 70 and 71 illustrate the difference between the galleries made by southern pine beetle and Ips engraver beetle.

Aerial damage appraisal surveys conducted over a 37-county area in south Georgia during January and October showed that pine mortality caused by Ips engraver beetles was steadily approaching an endemic level toward the end of the year. The January survey placed the estimated total pine volume killed by these beetles at 82,100 cords or 41,050,000 board-feet over the previous 4-month period. Since January 1955 there has been a 73 percent reduction in pine mortality, as indicated by the 22,250 cords or 11,125,000 board-feet killed from July to October in the same area. This outbreak, which started in early summer 1954, is one of the most extensive and severe ever recorded for this group of bark beetles in the Southeast. The total volume killed by these beetles in south Georgia in 1955 was estimated as 18,375,000 board-feet, or 25 percent of the total volume killed by Ips in the entire Southeast in 1955.

The last large outbreak of these beetles in south Georgia occurred from October 1931 to May 1932. Examination of rainfall records for this area showed that both outbreaks coincided with periods of severe drought. Pine engraver beetles usually confine their attacks to decadent trees; however, during dry periods these insects are capable of attacking and killing otherwise healthy, vigorous pines.

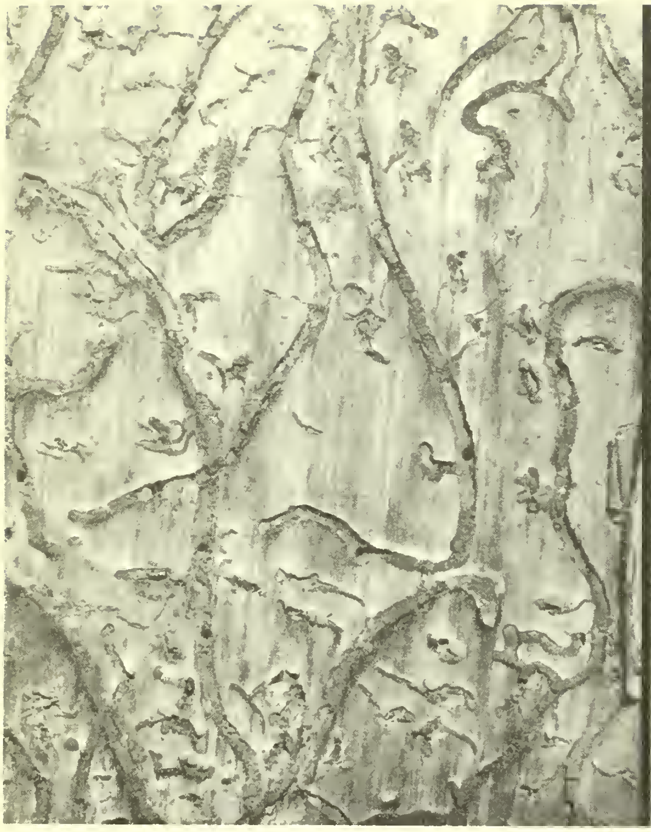


Figure 70.--Egg galleries of the southern pine beetle in the inner bark of yellow pine. Note meandering pattern and boring dust packed tight in the egg and larval galleries. Larval galleries are short because the larvae spend most of their lives in the outer bark.

Figure 71.--Egg galleries of the large pine engraver beetle, Ips calligraphus, in the inner bark of yellow pine. Note that the galleries are generally straight, follow the grain of the wood, and are free of boring dust. Larval galleries extend out from egg galleries. Larvae spend their lives entirely in the inner bark.

A comparison of forest type estimates between aerial strip sampling with the "electric operations recorder" and Forest Survey data was made of 37 counties in south Georgia. The combined pine and pine-hardwood acreage from the Forest Survey was 4,708,383 acres, and the estimate with the use of the "operations recorder" was 4,709,218 acres, or only .02 of 1 percent difference. The accuracy obtained in estimating broad forest type acreage by this new aerial sampling technique is expected to lead to its wider use.

Black Turpentine Beetle

The black turpentine beetle has been causing heavy pine mortality throughout south Georgia and north Florida since 1950. In the 37-county area of south Georgia surveyed this year, it was estimated that 18,595,000 board-feet of merchantable pine had been killed by the black turpentine beetle in 1954 and 18,375,000 board-feet in 1955, in addition to that killed by Ips engraver beetles. Heavy losses were also sustained throughout the gum belt of northern Florida this year; however, surveys were not conducted to ascertain the full extent of damage in that area. The total pine volume mortality caused by the beetle throughout the Southeast in 1955 is estimated at 37 million board-feet.

A total of 6,000 attacked pines were chemically treated on the Osceola National Forest, Florida, during the last half of 1955. It is believed that low water table and deficient soil moisture contributed to tree weakening and subsequent attack by the beetle. Naval stores operations will be resumed on the Osceola National Forest in 1956 on a limited scale; turpentining was stopped for several years because of heavy beetle attacks.

On two large study areas in Baker and Putnam Counties, Florida, pines received a basal spray of 1 percent BHC (gamma) in diesel oil, following initial attack (fig. 72) at biweekly intervals from March to October and at monthly intervals during the winter. After 15 months of systematic treatment, 90-percent control of stand mortality was obtained. This control is the result of two effects of the spray: the incidence of trees attacked is reduced 70 percent by lowering the beetle population; and the incidence of mortality of attacked trees is reduced 70 percent by suppressing existing attacks and preventing subsequent ones.

Intensive studies of the root-attack habit of this beetle on slash pine (fig.73) in northeastern Florida in 1955 revealed that: (1) root attacks are started soon after initial trunk attacks; (2) root attacks can hasten the death of the tree but by themselves do not appear capable of doing so, and thus they are dependent on the trunk activity; (3) root attacks are proportional in number to those on the trunk; and (4) roots can support a considerable beetle population.

Pales Weevil

The pales weevil (fig.74) has rarely been reported as a serious pest of pine seedlings in the South. During the period 1900-1950 few instances of damage were recorded in the literature. This rarity of weevil damage in the past might lead one to assume that the species is unimportant. But recent intensification of management practices, especially keeping land in continuous production, makes the insect a destroyer to be reckoned with.

The weevils are attracted to cutover or damaged pine stands. Before laying eggs and breeding in the stumps or basal section of weakened trees, the adults feed on the pine bark. Since they prefer tender bark, pine seedlings are a preferred source of food (fig.75). The feeding on the bark tissues by weevils entering a cutover area to lay eggs, and again several months later by weevils which have developed from eggs to adults in the stumps in the immediate area, injures the seedlings and in many cases causes their death. They have ruined many plantations.

One way of coping with pales weevil is to cut in a heavy seed year to encourage heavy reproduction, which may result in good stocking despite weevil losses. Another is to protect seedlings from attack. In 1955 a test was begun to determine the value of insecticides in such prevention. Some seedlings were dipped in insecticides prior to planting, whereas others were sprayed following planting. Spraying the seedlings and soil surface around them provided the greatest degree of protection. Dipping the seedlings provided less. Of the materials tested, water emulsions of 2 percent aldrin or heptachlor provided greatest protection to the seedlings without harming them.

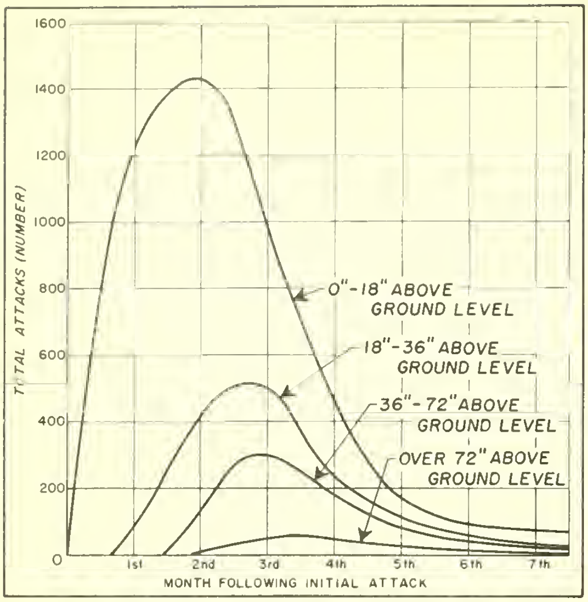


Figure 72.--Distribution of black turpentine beetle attacks on 256 slash pine by zone of attack (height above ground level). The delay in peak number of attacks following initial attacks, plus the fact that early attacks are limited to the basal 18 inches, makes control measures possible after attacks have started.

Figure 74.--An enlarged view of the pales weevil.

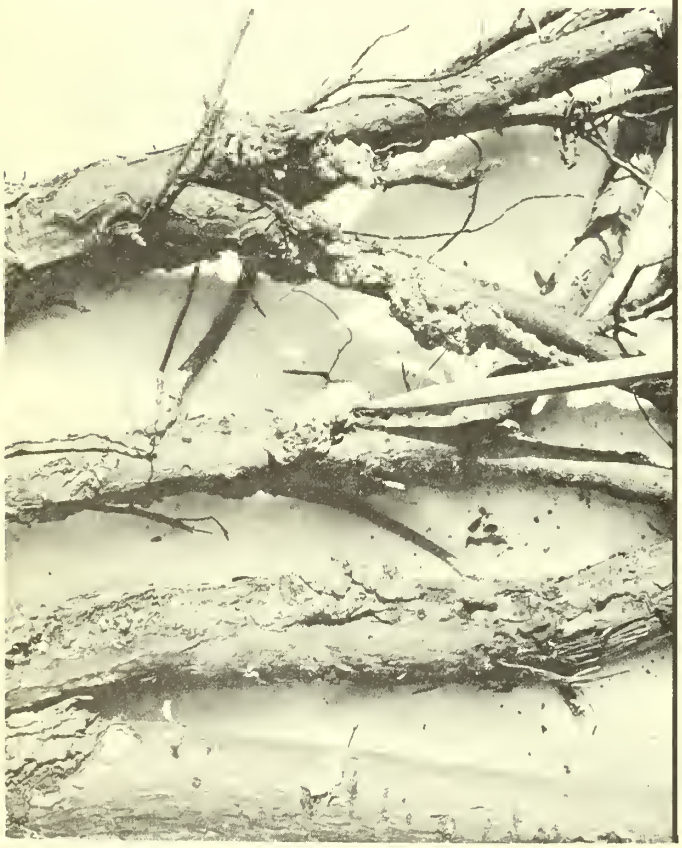


Figure 73.--Slash pine roots damaged by the black turpentine beetle. Note pitch tubes on lateral roots.

Figure 75.--Pine seedlings girdled and killed by feeding of pales weevil.

White Grubs

Serious white grub injury (fig. 76) to field-planted pine seedlings was reported during 1953 and 1954 at the Savannah River Project, AEC, near Aiken, South Carolina. Intensive control measures recommended for forest nursery seedbeds and field crops were not economically feasible.

Tests of insecticides and control methods were established during 1955 on slash pine planting stock. Water emulsions of aldrin, heptachlor, dieldrin, endrin, BHC, and isodrin were used as spot soil-drenches around seedlings, and as root-dips. Granular applications of aldrin and heptachlor were used at varying quantities per acre. The emulsions, particularly when used as root-dips, tended to injure the seedlings. However, no apparent damage occured from heptachlor as a 2.0 percent dip. BHC as a 2 percent root-dip caused nearly complete seedling mortality.

Effectiveness of the insecticides in white grub control was not determined. Grub injury to seedlings in 1955, a year after the severe infestation, was negligible in all plots because of a decline in the grub population.

Further tests of heptachlor and aldrin are planned to determine concentrations which may be used as root-dips to give the highest degree of grub control without injury to the seedlings. Grubs will also be introduced into pots with seedlings root-dipped in aldrin and heptachlor, to test these root treatments as control measures.

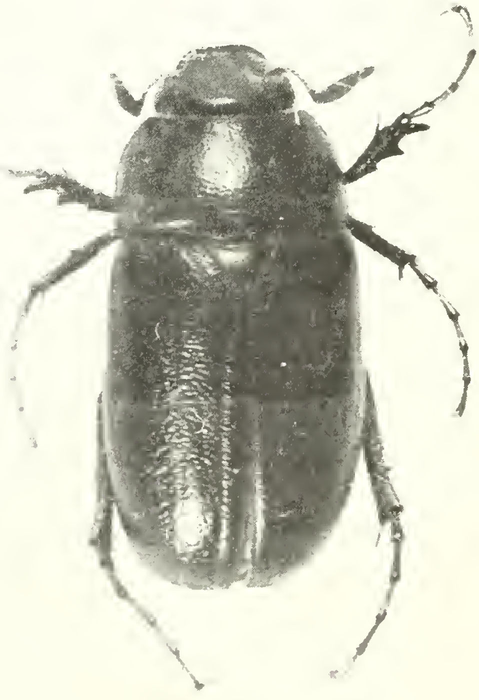


Figure 76.--At left, full-grown white grub. During the larval stage, the insect feeds on pine seedling roots and does serious damage. At right, adult stage of white grub (known as June beetle). Little damage to pine seedlings is done by the insect in this stage.

Radioisotope Studies

Radioisotopes were used in two studies to determine the movement of insects. White grubs at the Savannah River Project of the Atomic Energy Commission were tagged with Tantalum 182 wire. The treated grubs were released in plots representing different cover types to learn whether the roots of pine trees or other herbaceous cover were more attractive to grubs. Movements of the larvae through the soil are being determined by searching around the release points with scintillators and geiger counters.

Ten-thousand southern pine beetles were tagged by immersing them in Iridium 192 solution. These beetles were released in green timber in an isolated location on National Forest land to determine whether the movement of the beetles could be traced to surrounding areas of infestation.

When the area was examined a week after the release date, nine newly infested trees were found around the release point. Only three of the 1,327 beetles which left the containers were relocated by search with a scintillometer (fig. 77) in these nine newly attacked trees. Since the area was not disturbed nor the trees injured in any way, the mere presence of the large concentration of beetles must have attracted beetles from surrounding areas of infestation. This supposition indicates that a large concentration of beetles may induce southern pine beetle attacks on trees regardless of the condition of the host.

Fall Cankerworm

The fall cankerworm has caused severe defoliation of hardwood for 3 consecutive years in the Southern Appalachians from southwest Virginia to Georgia. The peak year of defoliation was 1953, when 29,500 acres were completely defoliated in western North Carolina alone. This year, defoliation occurred only in small isolated areas; however, it was necessary to spray several infested high-value recreational and scenic areas on the Blue Ridge Parkway to insure that tree mortality would not occur.

The decreased defoliation this season, despite moderate to heavy egg deposition, was attributed to egg parasites, adverse weather during egg hatching, and heavy predation by Carabid beetles. A study of egg hatching in one area showed that a common hymenopterous egg parasite, *Telenomus alsophilae*, caused 20 percent of the total egg mortality.

Cypress Beetle

A small beetle, *Systena marginalis*, was reported for the first time last year causing discoloration and mortality of cypress foliage in midsummer throughout south Georgia and north Florida. By late August of this year, as in 1954, the beetles had completed feeding on cypress in the same general area; however, damage to foliage was about one-half of that in 1954. The estimated size of the swarm was indicative of the declining damage, i.e., the beetle swarms in 1954 averaged 5,000 compared with an estimated 2,000 per swarm in 1955.

Figure 77.--Searching trees for southern pine beetles "tagged" with radioisotopes to determine the distance of their flight.

Nantucket Pine Moth

Studies were started in cooperation with the Georgia Forestry Commission with funds provided by the Georgia Forest Research Council to evaluate the effectiveness of various insecticides in controlling tip moths. Injury caused by the larval stage of these moths causes deformation, loss of height growth, and sometimes the death of small trees. The injury to the pine tips appears to be so severe at times that landowners are often discouraged from planting loblolly or shortleaf pine.

Twenty-nine insecticide formulations were used in the initial tests at Macon, Georgia. Of these, chlorthion, parathion, and 1 percent gamma benzene hexachloride were most effective. Chlorthion gave 95 percent kill of all stages, but had very little residual effect. Parathion, 0.5 percent, killed all larvae, but was ineffective against pupae. It gave moderate protection against the next generation that oviposited later. Benzene hexachloride killed 80 percent of the larvae present at the time of spraying (those in the last instance were not affected), and prevented reinfestation for 9 weeks.

A single application of DDT, endrin, dieldrin, aldrin, heptachlor, and toxaphene was relatively ineffective against the larvae. In addition, trees sprayed with a single application of these on June 17 were very heavily attacked by the broods that emerged in late August.

Pine Sawflies

A 25,000-acre block of pond pine, severely defoliated by sawflies in Berkeley County, South Carolina, during 1953, showed less than 25 percent defoliation in 1954 and was free of defoliation in 1955. Moderate to heavy defoliation of slash and longleaf pine by the red-headed pine sawfly was observed in mid-September in the Valdosta-Waycross, Georgia area.

PUBLICATIONS

by

MEMBERS OF THE STAFF, INCLUDING COOPERATORS

Calendar Year 1955

ALDRICH, R. C.
A method of plotting a dot grid on aerial photographs of mountainous terrain. Jour. Forestry 53(12): 910-913.

(Describes how to adapt the Radial Planimetric Plotter for use in transposing dots in a regular grid pattern to their correct topographic position on aerial photographs)

ANDERSON, W. C.
Can slabs from small sawmills be salvaged at a profit? South. Lumberman 191(2393): 185-188. Dec. 15.

(An analysis of possible profits from the sale of unbarked, hand debarked, and machine debarked slabs, and slabs from debarked logs)

BARBER, J. C., DORMAN, K. W., and JORDAN, R. A.
Slash pine crown width differences appear at early age in 1-parent progeny tests. Southeast. Forest Expt. Sta. Research Note 86.

(Crown-width of 3-year-old trees in 1-parent progeny tests shows strong correlation with crown width of mother tree. This holds true for both wide-crown and narrow-crown trees)

BENNETT, F. A.
The effect of pruning on the height and diameter growth of planted slash pine. Jour. Forestry 53(9): 636-638.

(The effect of pruning on height and diameter growth is given for the 2-step method of pruning in 5- and 11-year-old slash pine stands)

BENNETT, F. A.
Forest and Range Management Publications--Cordele Research Center. Southeast. Forest Expt. Sta., 13 pp.

(Annotated list starting August 1947 and ending July 1954)

BENNETT, F. A.
Growth of crowded 45-year-old slash pine after release. Southeast. Forest Expt. Sta. Research Note 77. Also in South. Lumberman 190(2379): 31. May 15.

(Because of their slow growth rate over a 5-year period, 45-year-old, short-crowned and partly suppressed slash pine are considered unsuitable growing stock)

BENNETT, F. A.
Wolf-trees--good gum producers. Naval Stores Rev. 65(3): 8.

(Trees averaging 14 inches d.b.h. and with two-thirds of their height in crown gave an average annual net return for gum of 55.4 cents per tree for a 3-year period)

BISHOP, G. N., and NELSON, T. C.
A winter key to the hickories of Georgia. Southeast. Forest Expt. Sta. Research Note 89.

(Includes 9 species with names corresponding to the latest check list)

BOYCE, J. S., Jr.
The implications of oak wilt for southern forestry. (Abs.) Assoc. South. Agr. Workers 52nd Ann. Conv. Proc., p. 107.

(Oak wilt is potentially serious to the South. Need surveys and control programs. Management will have to reckon with the wilt in affected areas)

BRENDER, E. V.
Drought damage to pines. The Forest Farmer 14(10): 7, 15.

(Mortality was highest on soils less than 16 inches deep and overlying impervious material. Mortality was less severe where there was 16 to 20 inches of soil overlying loose friable parent material, and least severe on soils with more nearly a normal profile)

BURNEY, H. W.
Reciprocating power bark hack and acid stimulator. U. S. Patent 2,725,674. Patented Dec. 6, 1955 (Patent Case No. 2701).

(Describes a gasoline-powered machine for chipping trees and applying acid to the face)

BYRAM, G. M.
Possible causes of blowup fires. Proc. Fourth Ann. Forestry Symposium, La. State U., pp. 24-34.

(Extreme fire behavior occurs when certain fuel and atmospheric conditions occur simultaneously)

CAMPBELL, R. A.
Does it pay to prune white pine in the Southern Appalachians? South. Lumberman 191(2393): 179-180. Dec. 15.

(Harvest-time profits per tree were $11.38 to $13.27; profits varied from $57 to $63 per M. bd. ft. for the pruned butt logs, or $700 per acre)

CAMPBELL, R. A.
Hold that poplar! South. Lumberman 191(2393): 150-151. Dec. 15.

(Gives board-foot volumes and dollar values obtained by holding 14-inch trees of grades A, B, and C for 20 years)

CAMPBELL, R. A.
Tree grades and economic maturity for some Appalachian hardwoods. Southeast. Forest Expt. Sta. Paper 53, 22 pp.

(Quality indices for trees were determined by tree grades, species, and number of logs per tree--the quality indices being further refined by constructing separate grade yield curves by the position of each log in the tree. A system of tree vigor classes also permits a more accurate estimate of growth)

CAMPBELL, W. A.
Utilizing Piedmont hardwoods. Forest Farmer 15(1): 10, 28.

(Discusses the volume of low-grade hardwoods and their potential uses)

CLEMENTS, R. W.
New plastic bottle as acid sprayer for gum producers. Naval Stores Rev. 65(3): 18. Also in AT-FA Jour. 17(9): 18.

(Thinner side walls reduce work in squeezing the bottle)

CLEMENTS, R. W. (As told by J. W. Dekle)
Get those extra dollars from your farm woodlands. AT-FA Jour. 17(10): 4-5. Also in Naval Stores Rev. 65(5): 12, 20-21.

(A gum farmer made a profit of $1.01 per face during a 4-year period by using modern methods)

COOPER, R. W.
Pre-commercial thinnings of pine bring earlier cash returns. South. Lumberman 191(2386): 32. Sept. 1.

(Thinning dense stands will more than pay for itself because of the increased growth of the residual trees)

COOPER, R. W.
Slash pine maintains maximum growth after light precommercial thinning. The Unit 59: 26-27.

(When a stand of 3,500 stems per acre was thinned, growth in cords was greater for 800 residual trees per acre than for 400 or 200 trees)

COPELAND, O. L., Jr.
The effects of an artificially induced drought on shortleaf pine. Jour. Forestry 53(4): 262-264.

(Lack of moisture curtailed diameter growth, shoot growth, and needle length. Needle color and nitrogen content remained normal. Branch dying started in lower crown)

COPELAND, O. L., Jr., and McALPINE, R. G.
The interrelations of littleleaf, site index, soil, and ground cover in Piedmont shortleaf pine stands. Ecology 36(4): 635-641.

(The mean percentage of littleleaf trees in the sampled stands in 18 South Carolina counties was 12.6. Of 13 soil factors analyzed, two--internal drainage and erosion--were highly correlated with littleleaf. Site index was highly correlated with internal drainage and inbibitional water values. With broomsedge or grass cover, littleleaf was high and site index and surface soil nitrogen low. Topography and aspect were not related to littleleaf)

CRUIKSHANK, J. W.
More hardwood pulpwood cut in South in 1954. Southeast. Forest Expt. Sta. Research Note 85.

(The number of cords of pine, hardwood, and chestnut pulpwood produced in each southern state, and percent change from 1953)

CRUIKSHANK, J. W., and ANDERSON, W. C.
Pine sawtimber stumpage prices in South Carolina, 1948-1954. Southeast. Forest Expt. Sta. Paper 57, 14 pp.

(Stumpage prices by years for price zones within the state and the effect of stand characteristics on price)

DEMMON, E. L.
Changes in the forest situation between surveys in Florida, Georgia, and South Carolina. The Unit 56: 52-61.

(Forest area, wood use, and net growth increased; total volume and sawtimber decreased)

DEMMON, E. L.
Forest Science: a quarterly journal of research and technical progress. Forest Science 1(1): 3-5.

(New technical journal aims to meet the needs of expanded research and more than 1,400 workers in the forest research field)

DEMMON, E. L.

Futures in research. The Forest Farmer 13(12): 7-9, 15-16. Also in AT-FA Jour. 17(10): 8, 12-13.

(New methods, new markets, and new developments in forest genetics are revolutionizing southern forestry)

DEMMON, E. L.

The reasons for research. American Forests 61(2): 13, 40, 42, 43.

(Fifty years of forest research in the U. S. have paid big dividends. Research cannot wait until practice catches up with knowledge--it must anticipate future needs)

DEMMON, E. L.

The role of research in southern forestry. South. Lumberman 191(2393): 98-100. Dec. 15.

(A roundup of past and present shows need for expanded program of forest research by federal, state, and private agencies)

DEMMON, E. L.

The U. S. Forest Service and the gum naval stores industry. Naval Stores Rev. Intn'l Yearbook, pp. 18-19, 77-78.

(Fifty years of improved techniques, from broadax to bark chipping and acid)

DEMMON, E. L.

What's ahead in southern forestry: Research. Forest Farmer Manual, 3rd ed., pp. 170-172. Atlanta, Ga.

(Research trends include more studies of plantation management, secondary forest types, and mechanical-chemical techniques; also choosing preferred species for given sites, and increased proportion of fundamental research)

DOOLITTLE, W. T.

Axe or machine girdling? South. Lumberman 191(2393): 152, 157. Dec. 15.

(Curves are presented showing machine and axe girdling time per tree as affected by species, d.b.h., and steepness of slope)

DORMAN, K. W.

Reforestation by natural means. Forest Farmer Manual, 3rd ed., pp. 58-60. Atlanta, Ga.

(Factors to consider in applying the seed-tree method are tree selection, species, and quality, time of cutting, number of trees to leave, and preparation of the seedbed)

DORMAN, K. W.
Short-time and long-time possibilities of selection in forest trees. Proc. Third South. Conf. on Forest Tree Improvement, pp. 31-35. New Orleans.

(Selection of improved tree types should be based on results of studies of inherent variation within each species. Many economically important plant varieties have been obtained by selection, but the process does not create new types--it merely isolates those occurring naturally)

DOYLE, H., and TARAS, M. A.
Amount of mismanufactured lumber received at North Carolina furniture plants. Leaflet issued by Furniture, Plywood and Veneer Council of N. C. Forestry Assoc., 2 pp.

(An exploratory study shows that almost 10 percent of the 4/4 lumber purchased by 10 furniture plants did not meet the National Hardwood Lumber Rules specification for size)

ECHOLS, R. M.
Aluminum foil boats for paraffin casting. Stain Technology 30(2): 65-67.

(Aluminum foil 0.0015 inch thick molded over wooden forms is very satisfactory)

ECHOLS, R. M., and MERGEN, F.
How to extract large wood samples from living trees. Jour. Forestry 53(2): 136.

(Successful method was to bore two holes to pith, insert flat-sided plugs as saw guides, saw between holes, and then chisel out the sample)

GRUSCHOW, G. F.
Diameter-increase after thinning white oak sprouts to one stem. Jour. Forestry 53(4): 287-288.

(Diameter growth was 50 percent greater; height growth was not stimulated)

HALLS, L. K.
Even in dry years you find cow feed in the forest. Farm and Ranch 85(3): 30. Also, with title Forest range proves haven for cattle during drought period, South. Livestock Jour. 15(1): 8, 71.

(Dry cows and steers gained in the spring and maintained summer weight despite a late freeze and severe drought in 1954. Wet cows performed nearly as well, and calves at weaning were slightly heavier than in previous years of greater rainfall)

HALLS, L. K.
Forage firebreaks. Progressive Farmer 70(11): 121.

(Plowed and seeded strips provide fire barriers and green feed for cattle)

HALLS, L. K.
Grass production under dense longleaf-slash pine canopies. Southeast. Forest Expt. Sta. Research Note 83.

(Normal grass production of 1,000 pounds per acre on open forest ranges declined consistently as tree canopies increased from 5 to 35 percent, but leveled off at about 300 pounds under the more dense canopies)

HANEY, G. P.
Shortleaf pine bibliography. Southeast. Forest Expt. Sta. Paper 48, 60 pp.

(Covers the literature from 1900 to June 1954 and groups it under 11 subjects)

HARGREAVES, L. A., Jr., and DORMAN, K. W.
Georgia starts pine seed orchards. South. Lumberman 191(2393): 189. Dec. 15.

(Scions of superior phenotypes in loblolly and slash pine will be grafted on run-of-the-mill seedlings in establishing 500 acres of seed orchards)

HAWLEY, N. R.
Integration of products for a 50-year partnership in forest research. AT-FA Jour. 17(4): 4-6.

(Lists products produced under intensive forest management)

HAWLEY, N. R.
Special cultural practices for a 50-year partnership in forest research. AT-FA Jour. 17(6): 5-6.

(Describes improvement cuts and other practices in intensive forest management)

HELLER, R. C., MERKEL, E. P., et al
Status of Ips pine engraver beetle epidemic in Southern Georgia. Southeast. Forest Expt. Sta. and Beltsville Forest Insect Lab. Forest Insect Survey Rpt. No. 7, 5 pp. December.

(A 0.78-percent aerial sample survey of 37 south Georgia counties was made with an electric recorder in October. The total pine volume mortality due to Ips pine engravers and the black turpentine beetle was estimated at 3,562,000 cu. ft.)

HEPTING, G. H.
The current status of oak wilt in the United States. Forest Science 1(2): 95-103.

(The wilt fungus and its manner of infection, range of the disease, methods of control, and status of control of wilt in eastern and midwestern states)

HEPTING, G. H.
Littleleaf. The Unit 58: 74-75.

(Status of littleleaf and research on control through genetics and soil management. Forest management in littleleaf areas is discussed)

HEPTING, G. H.
A southwide survey for sweetgum blight. Plant Dis. Rptr. 39(3): 261-265.

(Sweetgum blight of undetermined cause is common from Maryland to Louisiana, but only 1 percent of the gums tallied were blight-killed. On a sawlog volume basis, 86 percent of the board-foot volume was in trees healthy or only slightly affected. Elms were generally in as poor condition as sweetgum. Blight was worst on rolling uplands)

HOCKER, H. W., Jr.
Climatological summaries for selected stations in and near the southern pine region, 1921-1950. Southeast. Forest Expt. Sta. Paper 56, 11 pp.

(Temperature and precipitation data are summarized from the U. S. Weather Bureau records)

JOHNSTON, H. R., SMITH, R. H., and St. GEORGE, R. A.
Prevention and control of Lyctus powder-post beetles. South. Lumberman 190(2375): 72-74. March 15.

(Life history and methods of killing beetles in infested wood, and measures to prevent initial attack)

KEETCH, J. J., and GLADSTONE, M. C.
1954 forest fires and fire danger in Maine, New Hampshire, New Jersey, New York, Virginia, and West Virginia.

(Six separate state reports containing tables and graphs analyzing forest fires and fire danger)

KOWAL, R. J.
Insects commonly attacking forest trees and products in the South. Forest Farmer Manual, 3rd ed., pp. 22-29. Atlanta, Ga.

(Brief description and control measures of bark beetles, sawflies, and other insects attacking forest trees in the southern states)

KOWAL, R. J.

Ips beetles are killing pines: What shall we do about it? Southeast. Forest Expt. Sta. Research Note 81. Also in AT-FA Jour. 17(8): 10, 12, 15, Virginia Forests 10(3): 7, 15, and Naval Stores Rev. 65(3): 12-13.

(Description of Ips beetles found in the South and the use of BHC spray in No. 2 fuel oil for control measures)

KOWAL, R. J.

The southern pine beetle in Tennessee. Keep Tennessee Green News. p. 3. Aug.

(The southern pine beetle has killed approximately 19 million board-feet of yellow pine in eastern Tennessee since 1953. Cooperation, cutting, and spraying are needed)

KOWAL, R. J.

Where we stand in our fight against forest insects. Forest Farmer 14(10): 4-6.

(The mounting timber losses in the South indicate a need for cooperative action and education if forest industries are not to be endangered)

KOWAL, R. J., and BOYCE, J. S., Jr.

Diseases and insects. Forest Farmer Manual, 3rd ed., pp. 172-173. Atlanta, Ga.

(New insecticides and experimental techniques are helping us in our fight against the insect and disease menace to our forests)

KULMAN, H. M.

Southern pine beetle outbreak on the Sumter National Forest, General Pickens District, South Carolina. Southeast. Forest Expt. Sta. Forest Insect Survey Rpt. No. 6, 3 pp. October.

(Survey shows 1,700 trees concentrated in high-value areas. Infestation is not associated with other areas of beetle activity)

LANGDON, O. G.

Clipping needles adversely affects survival of South Florida slash pine. Southeast. Forest Expt. Sta. Research Note 74. Also in Naval Stores Rev. 64(11): 14.

(Clipping the needles apparently upset normal functions of needles such as photosynthesis and respiration and caused a browning of needle tips and death of some seedlings)

LANGDON, O. G., and RUMMELL, R. S.

Cooperative forest and range management research in south Florida. Southeast. Forest Expt. Sta. Paper 51, 24 pp. Also, with title Intensive study expands project to improve south Florida range lands, Fla. Grower and Rancher 63(7): 10, 15.

(Major problems are illustrated by photographs, and progress toward their solution briefly discussed)

LEE, R. E., and SMITH, R. H.

The black turpentine beetle, its habits and control. South. Forest Expt. Sta. Occas. Paper 138, 14 pp.

(Life history and habits of the black turpentine beetle and the use of BHC sprays to control infestation in stumps and living trees)

LOTTI, T.

Summer fires kill understory hardwoods. Southeast. Forest Expt. Sta. Research Note 71.

(Annual summer fires were more effective than biennial fires)

LOTTI, T.

Yellow-poplar height growth affected by seed source. Tree Planters' Notes 22: 3.

(At the end of the third growing season the mountain strain averaged 4.4 feet in height and that from the Coastal Plain 7.9 feet)

LUTZ, J. F.

Hickory for veneer and plywood. Hickory Task Force Rpt. No. 1. Southeast. Forest Expt. Sta., 12 pp.

(Gives data on heating bolts and flitches for cutting; also lathe settings, drying schedules, and veneer yields)

McCLAY, T. A.

Loblolly pine growth as affected by removal of understory hardwoods and shrubs. Southeast. Forest Expt. Sta. Research Note 73.

(Growth was as high on the untreated plots as on areas where the understory hardwoods had been eliminated or removed annually)

McCLAY, T. A.

The relation of growth to site and residual density in loblolly pine pulpwood stands. Southeast. Forest Expt. Sta. Research Note 78.

(Gives curves showing effect of site and residual density on periodic annual growth for a 9-year period after cutting in even-aged loblolly pine pulpwood stands)

McCLAY, T. A., and PAWEK, H. J.
The southern pine log grades; their application in a stumpage appraisal. South. Lumberman 190(2379): 70, 72, 74, 76. May 15.

(Gives average percentage of yard lumber-grade recovery by log diameters and grades for loblolly pine in the central Atlantic Coastal Plain)

McCORMACK, J.F.
An allowance for bark increment in computing tree diameter growth for southeastern species. Southeast. Forest Expt. Sta. Paper 60, 6 pp.

(Describes a method of taking bark growth into account in computing tree diameter growth, and presents a set of growth factors for use with southeastern species)

McCORMACK, J. F.
Forest statistics for the Northern Coastal Plain of North Carolina, 1955. Southeast. Forest Expt. Sta. Forest Survey Release 45, 44 pp.

(Statistics on forest area, timber volume, growth, and cut, with trends in forest area and timber volume)

McCORMACK, J. F.
17-year trends of timber volume in the Northern Coastal Plain of North Carolina. Southeast. Forest Expt. Sta. Research Note 80.

(Comparison of timber volumes found by the Forest Survey in 1937 and 1955)

McGREGOR, W. H. D.
In ten years, improved woodlands and a cash income. Fla. Grower and Rancher 63(2): 16, 48.

(Average annual return was $2.72 per acre from stumpage and $6.82 from labor, making a net hourly return of $0.79 per man-hour of labor)

MERGEN, F.
Air-layering of slash pines. Jour. Forestry 53(4): 265-270.

(The feasibility of air-layering as a technique in asexual propagation of slash pine is demonstrated)

MERGEN, F.
Anatomical study of slash pine graft unions. Quart. Jour. Fla. Acad. Sci. 17(4): 237-245.

(The pith and phloem were active in forming a union of stock and scion which was usually complete in about 6 weeks)

MERGEN, F.
Grafting slash pine in the field and in the greenhouse. Jour. Forestry 53(11): 836-842.

(Summarizes experiments with cleft, veneer or side-slit, and bottle grafts in the greenhouse and field)

MERGEN, F.
Inheritance of deformities in slash pine. South. Lumberman 190(2370): 30-32. Jan. 1.

(Progeny after open pollination of a crooked slash pine were 76 percent crooked; those of the same tree crossed with a straight tree were 68 percent crooked; those of the straight tree used as a female parent tree in other crosses were 41 percent crooked)

MERGEN, F.
Rooting and grafting of slash pine. Proc. Third South. Conf. on Forest Tree Improvement, pp. 88-94. New Orleans.

(Describes successful techniques for rooting, grafting, and air-layering)

MERGEN, F.
Vegetative propagation of slash pine. Southeast. Forest Expt. Sta. Paper 54, 63 pp.

(Presents details of many experiments in asexual propagation of the species)

MERGEN, F., and ECHOLS, R. M.
Number and size of radial resin ducts in slash pine. Science 121(3139): 306-307.

(Gives number and size of resin ducts in relation to age of tree up to 30 years and width of ring from 0.1 to 0.4 inch)

MERGEN, F., HOEKSTRA, P. E., and ECHOLS, R. M.
Genetic control of oleoresin yield and viscosity in slash pine. Forest Science 1(1): 19-30.

(Gum yield and viscosity were highly controlled genetically, while number and size of resin ducts were not)

MERGEN, F., ROSSOLL, H., and POMEROY, K. B.
How to control the pollination of slash and longleaf pine. Southeast. Forest Expt. Sta. Paper 58, 14 pp.

(Latest techniques are presented in true-to-life drawings)

MERKEL, E. P.
The southern pine beetle outbreak in western North Carolina and eastern Tennessee. Southeast. Forest Expt. Sta. Forest Insect Survey Rpt. No. 2, 32 pp. March.

(Aerial and ground surveys show a large increase over the 1954 southern pine beetle outbreak, with a total of 657, 000 infested trees, of which 217, 000 are on proposed control units)

MERKEL, E. P.
Southern pine beetle conditions in central Virginia. Southeast. Forest Expt. Sta. Forest Insect Survey Report No. 3, 3 pp. June.

(A 15-county survey indicated a decrease of southern pine beetle to near endemic status with 70 percent of the currently attacked trees showing pitched-out or unsuccessful attacks)

MERKEL, E. P., et al.
Ips pine engraver beetle epidemic in southern Georgia. Southeast. Forest Expt. Sta. Forest Insect Survey Rpt. No. 1, 6 pp. March.

(A 1.56-percent aerial survey of 37 counties in south Georgia indicated that Ips engraver beetles had killed 8,212,000 cubic feet of pine over a 4-month period)

MERKEL, E. P., et al.
Map rolling device for aerial sketch-mapping, Forest Service, USDA, Unnumbered sheet. Washington, D. C. July.

(Illustrations and instructions are given for the construction and use of a device which facilitates sketch-mapping on mosaic-type strip maps during aerial forest insect surveys)

MERKEL, E. P., and KULMAN, H. M.
Southern pine beetle and pine engraver beetle conditions in north-central South Carolina. Southeast. Forest Expt. Sta. Forest Insect Survey Rpt. No. 4, 4 pp. Sept.

(An aerial and ground survey of 8 counties indicated a strong decline in beetle activity. Approximately 40,000 trees were lost to southern pine beetle and 60,000 to Ips pine engraver beetle)

MERKEL, E. P., and KULMAN, H. M.
The southern pine beetle outbreak in western North Carolina and eastern Tennessee. Southeast. Forest Expt. Sta. Forest Insect Survey Rpt. No. 5, 12 pp. October.

(Infestations are on the decline throughout the area except for the Grandfather District, where 7,000 of the 24,000 tree infestations still are in need of chemical control)

MITCHELL, R. L.
Chemistry of hickory. Hickory Task Force Rpt. No. 2. Southeast. Forest Expt. Sta., 12 pp.

(As a source of chemical products, hickory is much like other hardwoods)

NELSON, R. M.
Calibration of fuel moisture sticks used in the East and South. Fire Control Notes 16(1): 40-42.

(Describes the weathering, humidifying, and calibration of fuel moisture sticks used at more than 650 fire danger stations)

NELSON, R. M.
How to measure forest fire danger in the Southeast. Southeast. Forest Expt. Sta. Paper 52, 22 pp.

(Sets forth standards for locating and operating forest fire danger stations)

NELSON, R. M.
The principles and uses of fire danger measurement. Proc. Fourth Ann. Forestry Symposium, La. State U., pp. 36-45.

(Describes the relation between Burning Index and number of fires and rate of spread; also how danger measurements can be used to rate the severity of seasons and to measure effectiveness of fire prevention efforts)

NELSON, T. C.
Chestnut replacement in the Southern Highlands. Ecology 36(2): 352-353.

(Replacement is primarily by advancement of species which were codominant with chestnut, and secondarily by invasions and the advancement of subordinate species, especially yellow-poplar)

NELSON, T. C.
Foreign visitors. American Forests 61(9): 17, 52-54.

(Technicians from 40 countries have visited and studied at the Coweeta Hydrologic Laboratory)

NELSON, T. C.
Forest management research in Georgia turns to Piedmont hardwoods. South. Lumber Jour. 59(11): 26, 76-77.

(A discussion of the importance of hardwoods, problems in their management, and the recently expanded research program)

OSTROM, C. E.
The tree improvement research program of the Southeastern Forest Experiment Station. Proc. Third South. Conf. on Forest Tree Improvement, pp. 101-104. New Orleans.

(Studies in variation and inheritance, project work in selective breeding, and many facilitating studies are being conducted concurrently at several Research Centers)

PETERSON, R. A., and WOOLFOLK, E. J.
Behavior of Hereford cows and calves on short grass range. Jour. Range Management 8(2): 51-57. March.

(Grazing habits observed for 24-hour periods in August and October in eastern Montana)

POMEROY, K. B.
Modern naval stores. Forest Farmer Manual, 3rd ed., pp. 104-106. Atlanta, Ga.

(A report on equipment, materials, techniques, and methods associated with modern practices)

POMEROY, K. B.
The southern forest. Forest Farmer Manual, 3rd ed., pp. 8-9, Atlanta, Ga.

(A discussion of southern forests in relation to area, volume, ownership, forestry practices needed, and management status)

POMEROY, K. B.
Naval stores. Encyclopedia Americana 20: 4-5. New York.

(A brief history of the naval stores industry in the United States with a list of the principal products)

POMEROY, K. B.
Research on the march. American Forests 61(10): 36-39, 58.

(Past and current research in the flatwoods region of Florida)

POMEROY, K. B.
Selecting slash pine for greater yields of turpentine. Proc. Third South. Conf. on Forest Tree Improvement, pp. 47-49. New Orleans.

(Gives evidence that gum-yielding ability is strongly inherited in slash pine and that it is possible to select and breed genetically superior trees)

POMEROY, K. B.
Up-grading slash pine seed sources. Proc. Soc. Amer. Foresters (1954) pp. 74-75. Also, with title How we get good pine seed, Progressive Farmer 70(10): 34D.

(Recommends selection of genetically superior trees and establishment of clonal seed orchards)

POMEROY, K. B., and MERGEN, F.
Better slash pine seed. Forest Farmer 14(6): 11. Also, with title Better forests a reality, National Container Digest 8(4): 5, 1954.

(An 86-acre seed producing area was created by removing undesirable phenotypes from a 20-year-old slash pine plantation)

RENSHAW, J. F.
Farm woodland management at Bent Creek. Farmers Federation News 36(3): 4-5.

(Reports that forestry operations on the farm woodlot can bring as much as $3 per acre per year from the sale of stumpage alone)

ROTH, E. R.
The results of 16 years' thinning of sprout oaks. (Abs.) Assoc. South. Agr. Workers 52nd Ann. Conv. Proc., p. 108.

(Cutting companion sprouts increases the decay hazard because wounds are created through which decay fungi enter the remaining stem. Recommendations are given on how to keep decay hazard at a minimum when thinning oak sprouts)

SCHOPMEYER, C. S.
Effects of turpentining on growth of slash pine: first-year results. Forest Science 1(2): 82-87.

(A reduction of 26 percent in growth during the first growing season was attributed to turpentining by two conventional methods)

SCHOPMEYER, C. S.
Gum yield and wood volume on single-faced naval stores trees. South. Lumberman 191(2393): 123-124. Dec. 15.

(After 2 years of chipping, volume increment in cubic feet of turpentined trees was 26 percent less than that of round trees. The method of turpentining made no apparent difference)

SCHOPMEYER, C. S., and LARSON, P. R.
Effects of diameter, crown ratio, and growth rate on gum yields of slash and longleaf pine. Jour. Forestry 53(11): 822-826.

(Gives yields in barrels of gum for trees of different characteristics)

SCHOPMEYER, C. S., and LARSON, P. R.
Gum-yield tables for slash and longleaf pine on poorer than average sites. Naval Stores Rev. 65(1): 14-15.

(Gives gum yields for trees 9 to 14 inches d.b.h., crown ratios of 0.20 to 0.55 percent, and 6 to 12 rings in the last inch of radial growth for slash pine on 70-foot sites and longleaf pine on 65-foot sites)

SCHOPMEYER, C. S., and SMITH, R. H.
Pitch moth damage to slash pine. AT-FA Jour. 18(3): 10-11. Also in Naval Stores Rev. 65(9): 6.

(The pitch moth Dioryctria, which mines under bark of small trees at the edge of wounds, has caused considerable damage to pruned stands in Florida. Control is effected by spraying wounds with a BHC solution)

SHIPMAN, R. D.
Preliminary test of direct seeding of longleaf pine in the South Carolina sandhills. Southeast. Forest Expt. Sta. Research Note 72. Also in Naval Stores Rev. 64(11): 8-9.

(This method of re-establishing longleaf may have merit if economical methods can be developed for protecting seed from birds and rodents)

SHIPMAN, R. D.
Furrows improve longleaf survival in scrub oak. South. Lumberman 190(2381): 70, 72. June 15.

(First year survival of longleaf pine on Sandhill sites where scrub oak predominates was highest for planting in furrows)

SHIPMAN, R. D.
Planting in furrows aids initial survival of longleaf in Sandhills. Southeast. Forest Expt. Sta. Research Note 82.

(After one year, survival was 71 percent for seedlings planted in furrows as compared to 57 percent where no release was given, 48 percent where all cover was eradicated, and 45 percent where 45 percent of the scrub oak stems were cut and the stumps poisoned)

SHIPMAN, R.D.
Better sweetgum control with 2, 4, 5-T. Southeast. Forest Expt. Sta. Research Note 84. Also in Virginia Forests 10(4): 13-14.

(Recommends adding an inexpensive wetting agent to water solutions or using oil as a diluent instead of water)

SMITH, R. H.
A control for the black turpentine beetle in south Georgia and north Florida. Southeast. Forest Expt. Sta. Research Note 76. April. (Revised Oct. 1955).

(Life history and habits of the black turpentine beetle. The use of BHC sprays to control infestations in stumps and living trees)

SMITH, W. R.
The source of lumber for furniture plants in North Carolina. Booklet issued by Furniture, Plywood and Veneer Council of N. C. Forestry Assoc., 5 pp.

(A survey showing source and species of lumber used by the North Carolina furniture plants)

SMITH, W. R.
The economic importance of wood residue in the South. Forest Prod. Jour. 5(3): 33-35.

(Gives general information on waste volume, survey methods, and potential uses of wood residue)

SMITH, W. R., ENGLERTH, G. H., and TARAS, M. A.
Wood residue in North Carolina--raw material for industry. Resource-Industry Series No. 8. N. C. Dept. Conserv. & Devlpmt., 59 pp.

(A survey of the various wood-using industries of North Carolina, giving waste volume, the manner in which it is disposed, its availability, and potential uses)

SNOW, A. G., Jr.
Naval Stores production methods. Forest Farmer Manual, 3rd ed., pp. 93-94. Atlanta, Ga.

(Discusses methods such as selection of trees for cupping, number of faces per tree, use of bark chipping and acid, chipping without acid, and disposal of worked out trees)

SOUTHWELL, B. L., and HALLS, L. K.
Supplemental feeding of range cattle in longleaf-slash pine forests of Georgia. Jour. Range Mgt. 8(10): 25-30.

(A 5-year report on supplemental feeding of cattle in longleaf-slash pine ranges. Cottonseed meal fed year-round and seasonally was compared with improved pastures as supplement to forest range)

SPEERS, C. F.
Insects which attack pine seedlings in the South. South. Lumberman 191(2393): 147-149. Dec. 15.

(The biology and control of Pales Weevil, Nantucket pine moth, pine sawfly, white grub, and pine webworm)

SUMAN, R. F., and HALLS, L. K.
Burning and grazing affect physical properties of coastal plain forest soils. Southeast. Forest Expt. Sta. Research Note 75.

(Volume-weight and water-absorbing properties of coastal plain soils are altered through compaction effects of grazing when litter is removed by burning)

TODD, A. S., Jr.
How much wood in a cord of pine slabs? Southeast. Forest Expt. Sta. Research Note 87.

(Cubic feet of bark-free wood per cord of rough slabs, by average log diameter and species)

TODD, A. S., Jr.
Pulpwood from small sawmill and logging residues: problems and opportunities. Jour. Forestry 53(6): 416-419.

(Volumes available, location, concentration, and current market value in a typical area of the Southeast)

TODD, A. S., Jr., and ANDERSON, W. C.
How to estimate the output of slabs at small pine sawmills. Southeast. Forest Expt. Sta. Research Note 79.

(An estimating method based on a tally of logs and counts of slabs and edgings)

TODD, A. S., Jr., and ANDERSON, W. C.
Size, volume, and weight of pine slabs and edgings in the South Carolina Piedmont. Southeast. Forest Expt. Sta. Paper 49, 21 pp.

(Information on characteristics that have a bearing on salvage for pulping)

TROUSDELL, K. B.
Hurricane damage to loblolly pine on Bigwoods Experimental Forest. South. Lumberman 191(2383): 35-37. July 15.

(Damage was light in dense young timber stands, and heavy in open stands of mature timber)

TROUSDELL, K. B.
Loblolly pine seed tree mortality. Southeast. Forest Expt. Sta. Paper 61, 11 pp.

(Where eight seed trees were left per acre, less than 1 percent of the trees died per year during the average regeneration period of 3.3 years. Lightning and wind caused half the mortality)

TROUSDELL, K. B., and HOOVER, M. D.
A change in ground-water level after clearcutting of loblolly pine in the coastal plain. Jour. Forestry 53(7): 493-498.

(Fifteen weeks' measurements show water table highest under clearcut strips, lower at stand edges, and lowest under a forest stand)

WAHLENBERG, W. G.
Six thinnings in a 56-year-old pure white pine plantation at Biltmore. Jour. Forestry 53(5): 331-339.

(Total production with thinning was 50 percent greater in board-feet. The average stumpage value of each surviving tree on the unthinned plot is now 80 cents; the average reserve tree on the thinned plot is worth $3.05. On a per-acre basis the total stumpage value gained by thinning was $198.40)

WENGER, K. F.
Growth and prospective development of hardwoods and loblolly pine seedlings on clearcut areas. Southeast. Forest Expt. Sta. Paper 55, 19 pp.

(Gives 3 aids in estimating future seedling dominance)

WENGER, K. F.
Height growth of loblolly pine seedlings in relation to seedling characteristics. Forest Science 1(2): 158-163.

(Previous growth is the best characteristic to use as an indicator of future growth)

WENGER, K. F.
Light and mycorrhiza development. Ecology 36(3): 518-520.

(Mycorrhiza development was best on roots in the A horizon and where seedlings received full sunlight)

WENGER, K. F.
Loblolly pine reproduction: success or failure? South. Lumberman 190(2373): 68, 70, 72. Feb. 15.

(Pine seedlings under large residual hardwoods or in dense clumps of small hardwoods are poor prospects for survival, while seedlings in well-defined openings are good prospects)

WENGER, K. F.
Seed tree requirements in loblolly pine. South. Lumberman 191(2393): 116-118. Dec. 15.

(Gives number of trees by diameter which are required to obtain desired reproduction, in percent of milacres stocked)

WILLIAMS, R. E., CASSADY, J. T., HALLS, L. K., and WOOLFOLK, E. J.
Range resources of the south. Ga. Agr. Expt. Sta. Bul. n. s. 9, 31 pp.

(The nine main grazing types of the extensive southern range are described as to extent, estimated acreage, best season of use, grazing capacity, and special problems)

WOOLFOLK, E. J.
Range improvement and management problems in Argentina. Jour. Range Management 8(6): 260-264. Nov.

(Overgrazing has resulted in reduced plant cover, disappearance of good forage species, increases in undesirable plants, heavy soil losses, and reduced grazing capacity in parts of the Pampa and most of Patagonia)

ZAK, B.
The grafting of shortleaf and other pine species. Southeast. Forest Expt. Sta. Paper 59, 13 pp.

(Describes the use of cleft, bottle, side, veneer, and "soft tissue" grafts, both indoors and out. Factors affecting the success of grafting are discussed. Soft tissue grafts were especially successful, both intraspecific and interspecific, and are recommended wherever feasible)

ZAK, B.
Inheritance of resistance to littleleaf in shortleaf pines. Southeast. Forest Expt. Sta. Research Note 88.

(In growth and resistance to Phytophthora root rot, open-pollinated progeny from littleleaf trees were inferior to open-pollinated progeny from associated healthy trees)

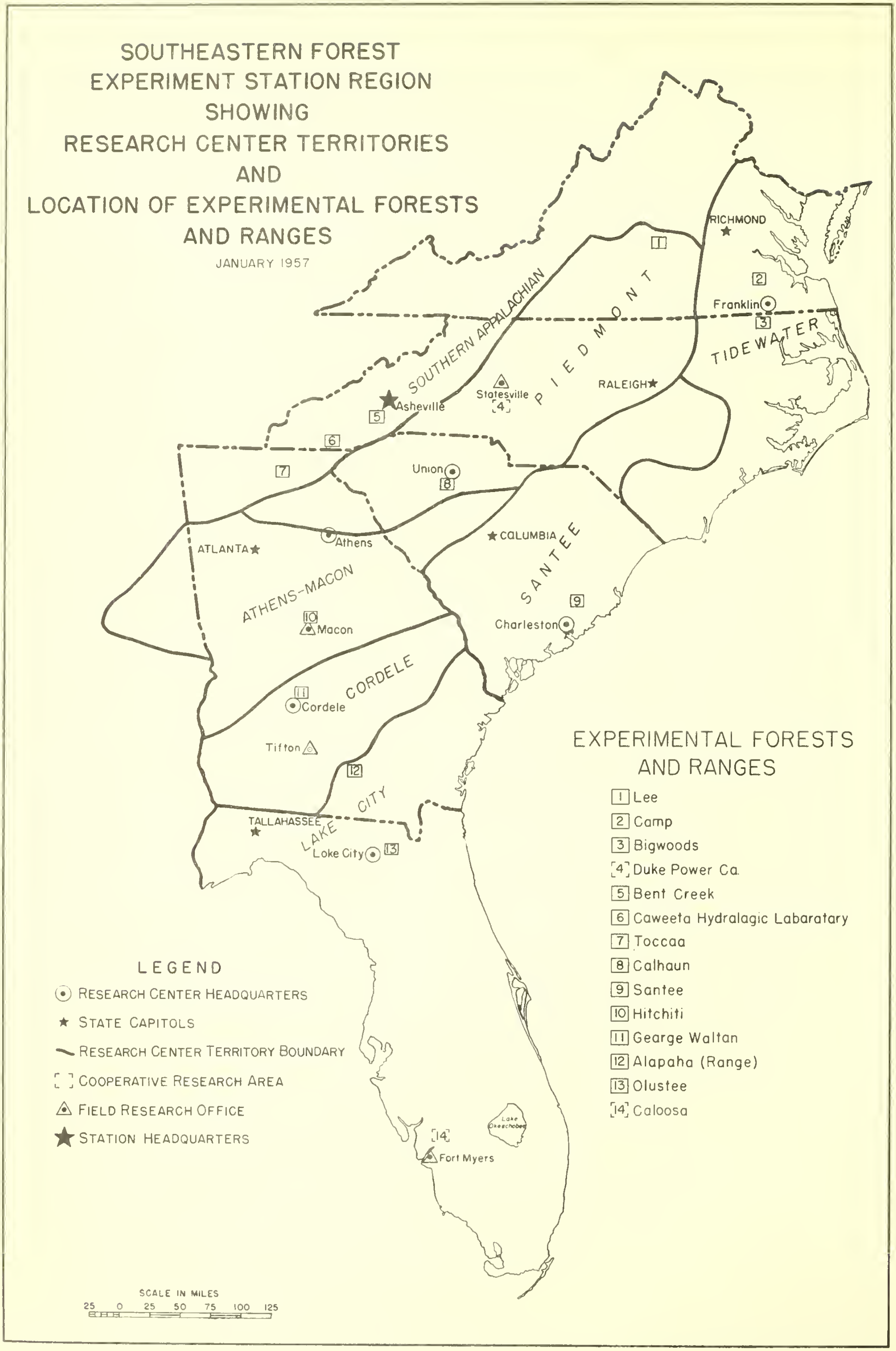
February 1957

Annual Report 1956

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

Joseph F. Pechanec,
Director

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE


SOUTHEASTERN FOREST
EXPERIMENT STATION REGION
SHOWING
RESEARCH CENTER TERRITORIES
AND
LOCATION OF EXPERIMENTAL FORESTS
AND RANGES
JANUARY 1957
SOUTHERN APPALACHIAN
PIEDMONT
TIDEWATER
ATHENS-MACON
SANTEE
CORDELE
LAKE CITY
RICHMOND
Franklin
RALEIGH
Statesville
Asheville
Union
ATLANTA
Athens
COLUMBIA
Macon
Charleston
Cordele
Tifton
TALLAHASSEE
Loke City
Fort Myers
Lake Okeechobee
EXPERIMENTAL FORESTS
AND RANGES
1 Lee
2 Camp
3 Bigwoods
4 Duke Power Ca.
5 Bent Creek
6 Caweeta Hydralagic Labaratary
7 Toccaa
8 Calhaun
9 Santee
10 Hitchiti
11 Gearge Waltan
12 Alapaha (Range)
13 Olustee
14 Caloosa
LEGEND
RESEARCH CENTER HEADQUARTERS
STATE CAPITOLS
RESEARCH CENTER TERRITORY BOUNDARY
COOPERATIVE RESEARCH AREA
FIELD RESEARCH OFFICE
STATION HEADQUARTERS
SCALE IN MILES
25 0 25 50 75 100 125

The wide scope of research accomplishments presented in the following pages would not have been possible without the very substantial cooperation of land-grant colleges and other educational institutions, state and federal agencies, industries, and individuals. The report gives summaries only of the Station's major accomplishments. The publications listed in the final pages describe our results in greater detail. The report is arranged by divisions, though much of the work is done by research workers at the eight research centers shown on the accompanying map.

DIVISIONS AND CENTERS

SOUTHEASTERN FOREST EXPERIMENT STATION

December 31, 1956

Research Divisions	Officer in Charge
Forest Economics	James F. McCormack
Watershed Management	H. Glenn Meginnis
Forest Fire	Ralph M. Nelson
Forest Utilization	Walton R. Smith
Range Management	H. Glenn Meginnis
Forest Diseases	George H. Hepting
Forest Insects	R. Joseph Kowal
Forest Management	Carl E. Ostrom

Principal Field Centers	Officer in Charge
Athens-Macon Research Center, Athens, Ga.	William A. Campbell
Cordele Research Center, Cordele, Ga.	Norman R. Hawley
Coweeta Hydrologic Laboratory, Franklin, N. C.	Donald E. Whelan
Lake City Research Center, Lake City, Fla.	Thomas F. McLintock
Piedmont Research Center, Union, S. C.	Louis J. Metz
Santee Research Center, Charleston, S. C.	Thomas Lotti
Southern Appalachian Research Center, Asheville, N. C.	James F. Renshaw
Tidewater Research Center, Franklin, Va.	George F. Gruschow

CONTENTS

Page

Page

Annual Report, 1956

Southeastern Forest Experiment Station

FOREST ECONOMICS

Progress of the Forest Survey

In March 1956, field work on the second forest survey of Virginia was started in the Coastal Plain area. In July the tempo of work quickened as the regular survey staff was increased and two cooperative cruising teams were added. The Virginia Forest Service, seven Virginia pulp companies, one Pennsylvania company, Virginia Forests, Inc., and TVA are now providing either manpower or financial assistance. By the year's end, 8.5 million acres, or 54 percent of the forest land in the State, had been surveyed (fig. 1). Work is continuing in the northern Piedmont section, and the State should be completed by June 1957. Statistical data compiled from the survey will be published at intervals throughout 1957 as office summaries become available.

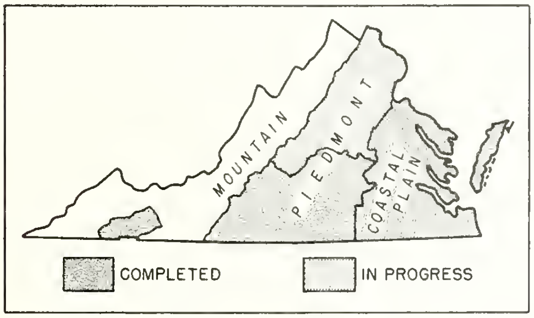


Figure 1.--Progress of the forest survey in Virginia.

South Again Shatters Pulpwood Production Record

Twelve southern states joined in producing a total of 18,014,600 cords of pulpwood during 1955 to set a new production record for the sixth straight year, and to maintain the South's position as the leading pulpwood region in the United States. The production gain amounted to 1.7 million cords, or 11 percent more than the cut in 1954. In this record year, pulpwood received at southern mills accounted for 58 percent of total domestic receipts at all U.S. pulpmills.

Georgia led the southern states by a wide margin, with a harvest of 3.8 million cords, about one-fifth of the regional cut (fig. 2). All other southern states except Arkansas, Tennessee, and Oklahoma produced more than one million cords each. Yellow pine pulpwood made up 86 percent of the total cut, but hardwoods gained in prominence. Last year, 2.5 million cords of hardwood species were used, an increase of 18 percent over 1954.

An important trend within the industry was noted in the much heavier use of sawmill slabs, veneer cores, cull crossties, and other wood residues for pulp. The volume of these formerly discarded materials converted to chips was 374,100 cords, a threefold increase during the year.

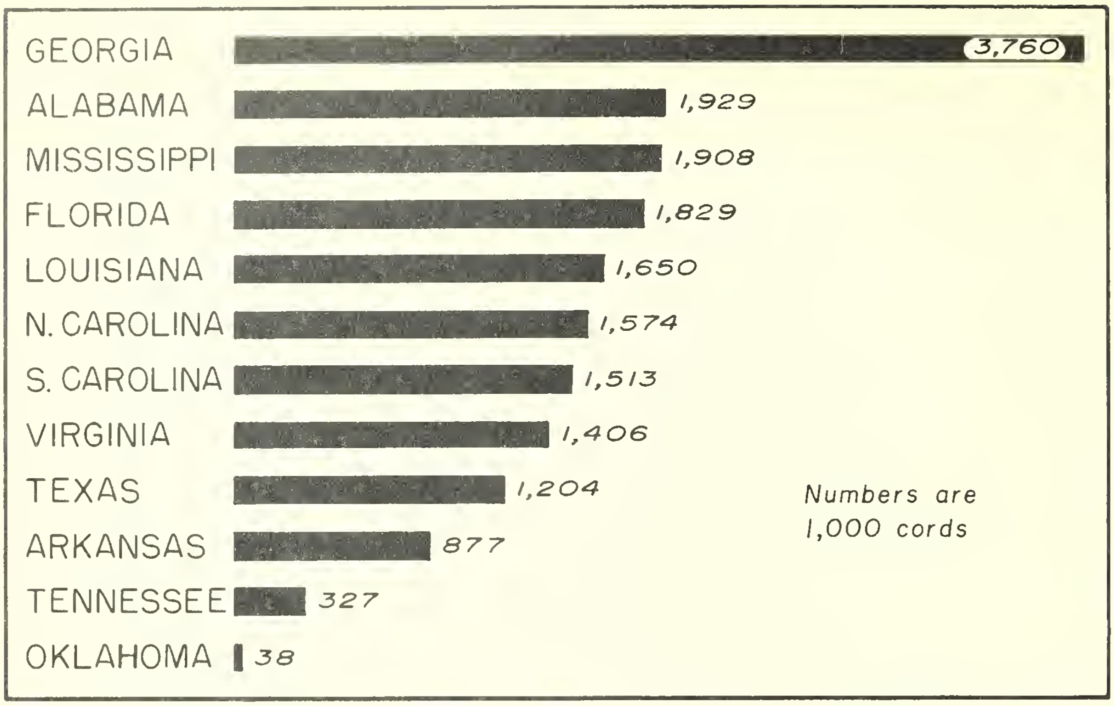


Figure 2.--Pulpwood production in the South, 1955.

The outlook in the South is for still greater use of pulpwood. A total of 73 mills now draw wood from this region. Sixty-nine of these mills, with a current daily pulping capacity of 34,100 tons, are located in southern states, and almost every company is actively engaged in expanding production facilities. Eight new pulp mills are either under construction in the South, or definite plans for their construction have been announced.

New Survey Reveals Changes in North Carolina's Timber Supply

In January of 1956, a resurvey of North Carolina's timber resources was completed, showing a number of important changes and trends since the earlier survey in 1938. North Carolina now has more land to grow timber. In the 17 years between surveys, enough cropland was abandoned and allowed to revert to forest in excess of land cleared to increase the area of commercial forest land from 18.1 million to 19.3 million acres, an increase of 1.2 million acres. Forest land available for timber production now makes up 62 percent of the total land area in the State.

Also, the forest land is now better stocked with timber. Between surveys, the volume of growing stock in the State increased 17 percent, or about 32 million cords (table 1). Even with the big increase in forest area, the volume of growing stock per acre increased from 10.5 to 11.5 cords.

The resurvey also shows a decrease in the area in pine and oak-pine type, but this was offset by an increase in pine stocking on the remaining pine land. In spite of a 1.6-million-acre drop in the area of pine and oak-pine type, the total volume of softwood growing stock remained about the same. The average volume per acre increased from 8.3 cords in 1938 to 9.7 cords in 1955.

Table 1.--Change in volume of all trees 5.0 inches d.b.h. and larger

Species group and class of material	1938	1955	Change	
	Thousand cords	Thousand cords	Thousand cords	Percent
Growing stock:	190,311	222,232	+31,921	+16.8
Yellow pines	96,520	97,634	+1,114	+1.2
Other softwoods	7,998	8,234	+236	+3.0
Soft hardwoods	43,047	56,769	+13,722	+31.9
Hard hardwoods	42,746	59,595	+16,849	+39.4
Culls 1/	30,587	41,491	+10,904	+35.6
All live trees	220,898	263,723	+42,825	+19.4

1/ Exclusive of hardwood limbs.

While the remaining pine and oak-pine stands are better stocked, the timber on the average is smaller. Pine poletimber volume increased 19 percent, but sawtimber dropped 6 percent (table 2). The volume of large sawtimber decreased 14 percent.

Table 2.--Change in growing-stock volume by size of timber

Size of timber	Softwoods			Hardwoods		
	1938	1955	Change	1938	1955	Change
	Thousand cords	Thousand cords	Percent	Thousand cords	Thousand cords	Percent
Poletimber	30,631	36,505	+19.2	32,434	50,332	+55.2
Sawtimber	73,887	69,363	-6.1	53,359	66,032	+23.8
Small	51,542	50,192	-2.6	23,358	32,621	+39.7
Large	22,345	19,171	-14.2	30,001	33,411	+11.4
All sizes	104,518	105,868	+1.3	85,793	116,364	+35.6

Also, the proportion of timber volume in hardwood and cull trees has increased. While softwood volume barely held its own, the total volume of hardwoods increased 36 percent, including a 24-percent increase in hardwood sawtimber. And the volume in cull trees, mostly hardwoods, increased 36 percent.

A substantial increase in timber growth, along with a slight decline in timber cut, has reversed the past downward trend in softwood sawtimber. Current growth is more than adequate to replace the volume of softwood sawtimber cut annually; even the large sawtimber is growing faster than it is being cut. The short-term timber supply outlook is quite favorable.

However, the trend toward smaller timber, more hardwoods, and more cull timber makes the long-term outlook less favorable. In 1938, sawtimber made up two-thirds of the growing-stock volume. During the past 17 years, this proportion has dropped to 61 percent and, if current trends continue, can be expected to drop to 55 percent by 1965. Currently, 80 percent of the timber cut comes from sawtimber.

Forest industries depend on softwoods for two-thirds of their timber needs. At the time of the first survey, softwoods comprised nearly half the total volume of timber; now the proportions are 40 percent softwood and 60 percent hardwood. And, if current trends continue, the softwood proportion will have dropped to 36 percent by 1965. With so much of the timber inventory in small timber and low-quality hardwoods, one of the principal aims in North Carolina should be greater production of pine and good hardwood to meet the steadily mounting demands of industry.

Changes and Trends in the Virginia Coastal Plain

The resurvey of the Coastal Plain of Virginia shows a slight increase in forest area, a marked shift from pine to hardwood types, and greater stocking in the smaller tree sizes.

Commercial forest area increased 148,000 acres, or 4 percent. Expansion of hardwood types has been rapid during the past 16 years. Table 3 shows a hardwood area increase of one-third million acres, or 22 percent. A large part of the shift has been from loblolly pine, which dropped 124,000 acres. Shortleaf pine and Virginia pine types have suffered even larger percentage decreases, although the acreages involved are much smaller.

The Virginia Coastal Plain has 14 percent more growing stock volume now than in 1940, but a much larger proportion of it is in hardwood trees. While softwood volume, nearly all yellow pine, remained about the same, soft hardwood timber, mainly gum and yellow-poplar, increased 17 percent, and hard hardwoods, consisting mainly of oaks and hickory, increased 47 percent.

Also, the timber is smaller on the average. Softwood poletimber and small sawtimber increased slightly, but large sawtimber dropped 18 percent (fig. 3). While soft hardwood poletimber and small sawtimber increased substantially, large sawtimber remained about the same. However, all sizes of hard hardwood timber increased substantially.

Table 3.--Comparison of commercial forest areas by forest type, 1940 and 1956

Forest type	1940	1956	Change	
	Thousand acres	Thousand acres	Thousand acres	Percent
Loblolly pine (including pond pine)	1,919	1,795	-124	-6
Shortleaf pine	164	137	-27	-16
Virginia pine	331	297	-34	-10
Hardwoods	1,505	1,838	+333	+22
All types	3,919	4,067	+148	+4

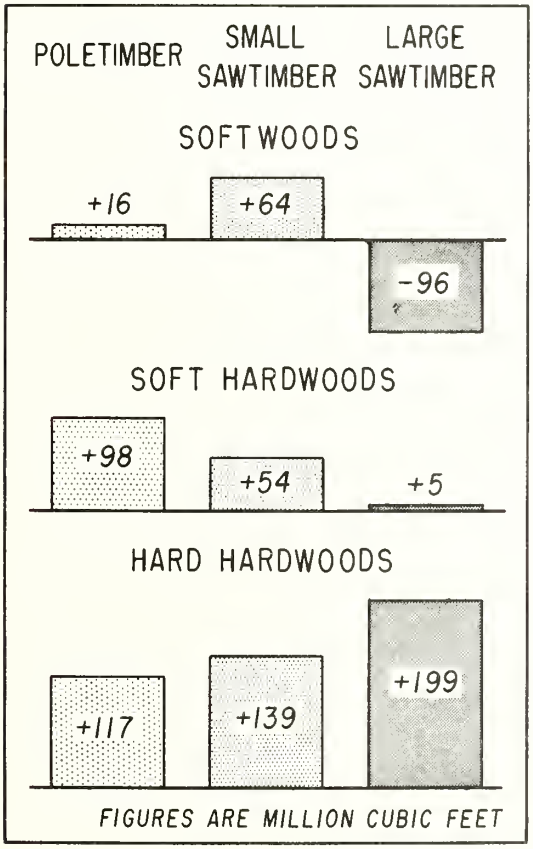


Figure 3.--Change in growing stock volume by species-group and size of timber between 1940 and 1956 in the Virginia Coastal Plain.

The Rising Price of Pine Stumpage

Southeastern pine stumpage now brings five times as much as it did 15 years ago. The rate of increase has been somewhat greater for sawtimber than for pulpwood timber (fig. 4).

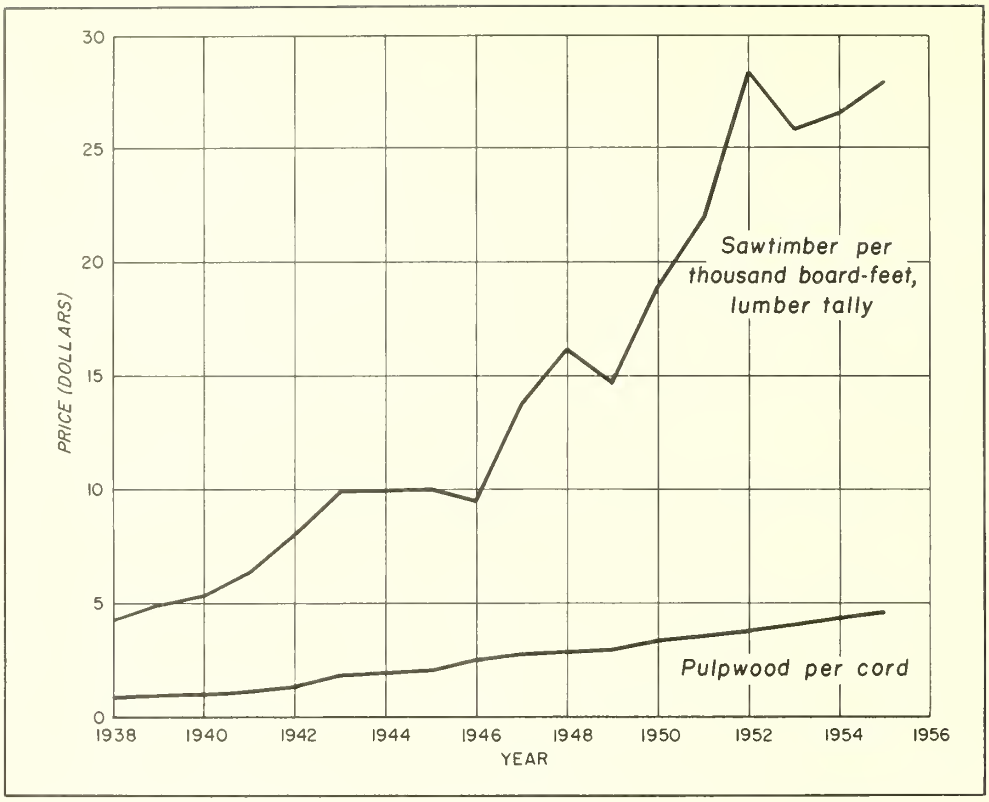


Figure 4.--Southeastern pine stumpage increased more than five times from 1938 to 1955.

Cost of Getting Chips from Small-Sawmill Residues

Will it pay to make pulp chips from small-sawmill residues? To answer this critical question, the costs of ten salvage methods possible with present equipment were compared (fig. 5). In converting barky slabs and edgings to bark-free chips and transporting them from the sawmill to the pulpmill, the elements of cost are the price paid for the slabs and edgings, plus the costs of debarking, chipping, handling, and transporting them. Each cost is affected by the location of processing, which may take place at the sawmill, the pulpmill, or a concentration yard.

At sawmills with log barkers, lumber production is increased when logs are first debarked and then sawed. The increase is due to higher yields from each log, and a reduction in downtime for saw filing. These benefits are not realized, of course, when unbarked logs are sawed and slabs and edgings are then debarked. Bark removal in either case will lower transportation cost since bark makes up one-third the volume of rough slabs and edgings and is valueless except for fuel. Unfortunately, the advantages of early bark removal are seldom realized because few sawmills can afford the large, expensive log barkers or slab barkers that do the job most efficiently; and the small slab barkers that sawmills can afford require too much labor. Similarly, the cost of chipping at small sawmills is high. Even the smallest chipper could process the full residue output of most small sawmills in half a day.

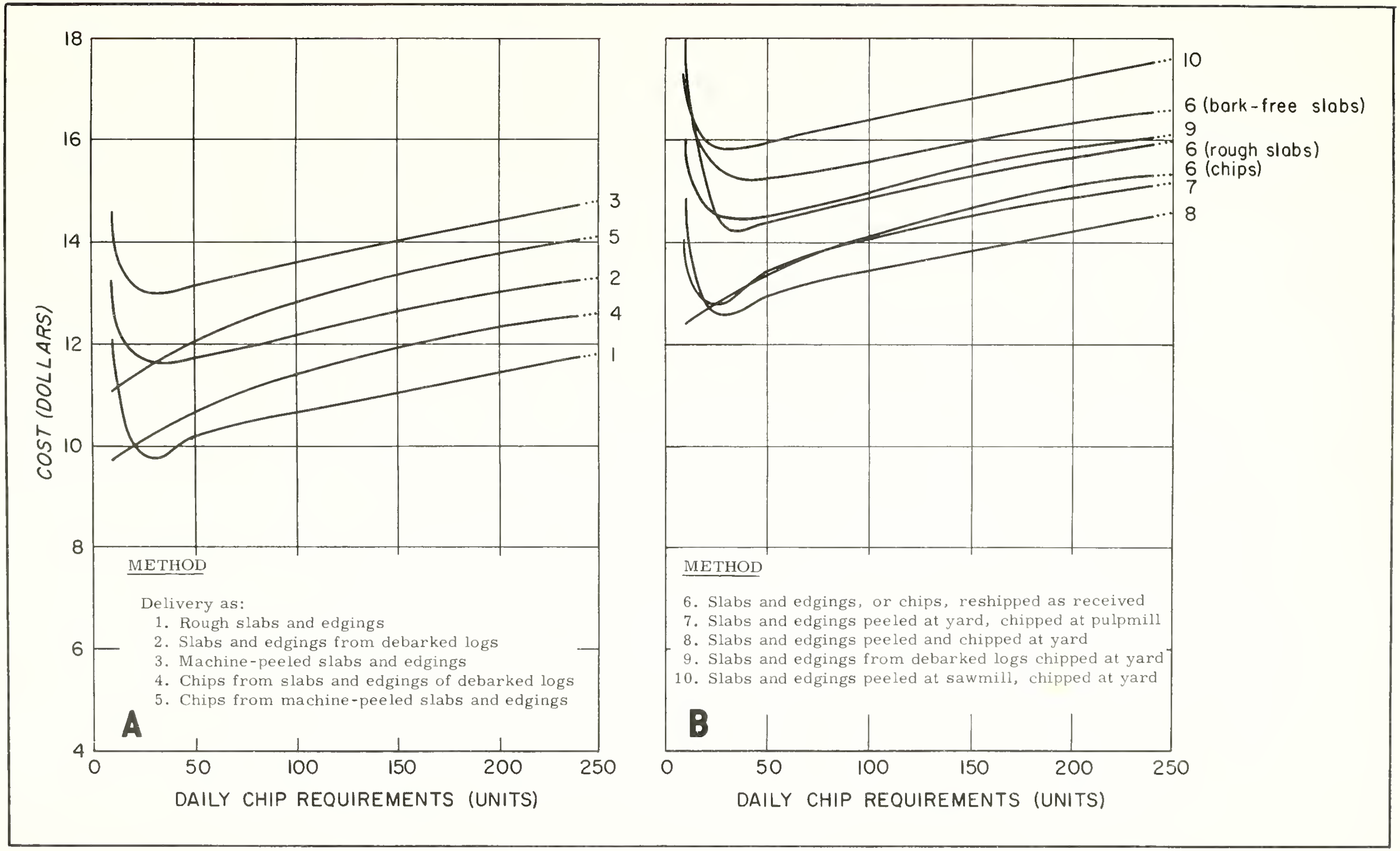


Figure 5.--Cost of unscreened chips per unit at pulpmill by ten salvage methods. A, When material is trucked from sawmill directly to pulpmill. B, When material is trucked from sawmill to concentration yard and reshipped by rail to pulpmill.

At the pulpmill, debarking and chipping cost much less than at the sawmill because larger volumes of residue can be processed. Also, closer control of quality makes possible more uniform chips which contain only small amounts of bark. Trucking costs, of course, are higher when barky slabs and edgings are hauled to the pulpmill.

Trucks that are small enough to reach small sawmills located in the woods have a short economical hauling distance. For longer hauls, rail freight is consequently lower. When sawmills are located some distance from the pulpmill, it is cheaper to transfer residues from trucks to freight cars at a concentration yard (usually a midpoint) than to truck them all the way. Concentration yards usually realize the same economies of large-scale production as pulpmills.

Obviously, it would be preferable to remove bark from residues at small sawmills to save the cost of transporting it. But debarking and chipping can be done so much more efficiently at pulpmills and concentration yards that the job can be done cheaper there even though rough slabs and edgings must be hauled. Thus, under present-day conditions the lowest-cost methods of producing chips from small-sawmill residues are those involving slab barker-chipper installations at pulpmills (Method 1) or at concentration yards (Method 8).

Forty Years Required to Grow a 12-Inch Loblolly Pine

On an average site in North Carolina, a loblolly pine can be expected to be 8 inches d.b.h. in 25 years and about 12 inches in 40 years.

These findings are the results of an analysis of height, age, and diameter measurements taken on 1,366 loblolly pine trees selected for site index determination on forest survey inventory plots scattered throughout the range of loblolly pine in North Carolina.

Figure 6, showing the size of loblolly pine by age and site index, was constructed by use of an estimating equation derived from these measurements. Computed diameters shown in the chart are not for average forest-grown trees but for selected dominant and codominant trees which have been in a relatively free-growing position throughout their lives. Thus, loblolly pine may be expected to attain these sizes under near optimum stocking condition in natural stands--perhaps under conditions which might be attained in well managed stands.

A Simplified Method of Slope Correction

A new approach to the problem of correcting for slope on circular sample plots was described in the Journal of Forestry, Vol. 54, July 1956. The method has been used the past 2 years on forest survey sample plots in North Carolina and Virginia Piedmont and mountains.

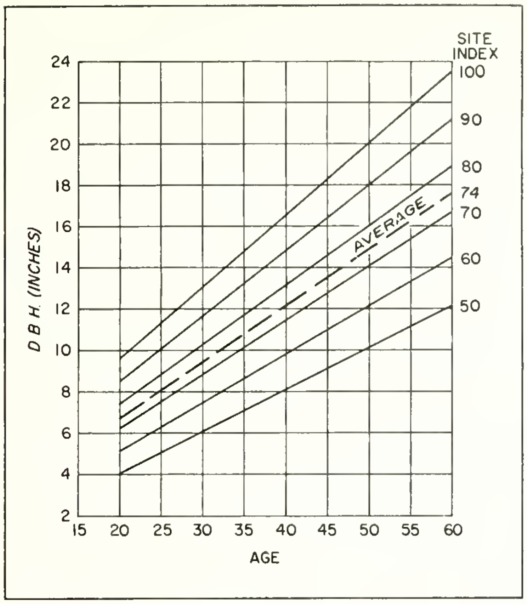


Figure 6.--Estimated growth of dominant and codominant loblolly pine throughout its range in North Carolina.

Briefly, each plot is given a slope classification based on measurement of the slope of its steepest diameter. A correction for the particular slope class is applied to the plot radius and used throughout measurement of the plot. The perimeter thus remains circular regardless of the amount of slope (figures 7 and 8). Application of the method is facilitated by painting the horizontal and adjusted plot radii on the steel tape used in plot measurement.

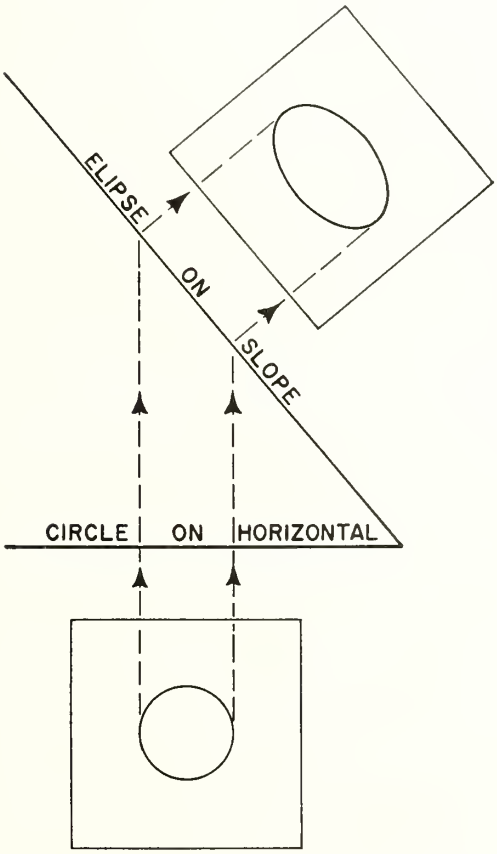


Figure 7.--A diagram of the usual sample plot on a steep slope. It is circular on the horizontal plane but forms an elipse when projected to the surface of the slope.

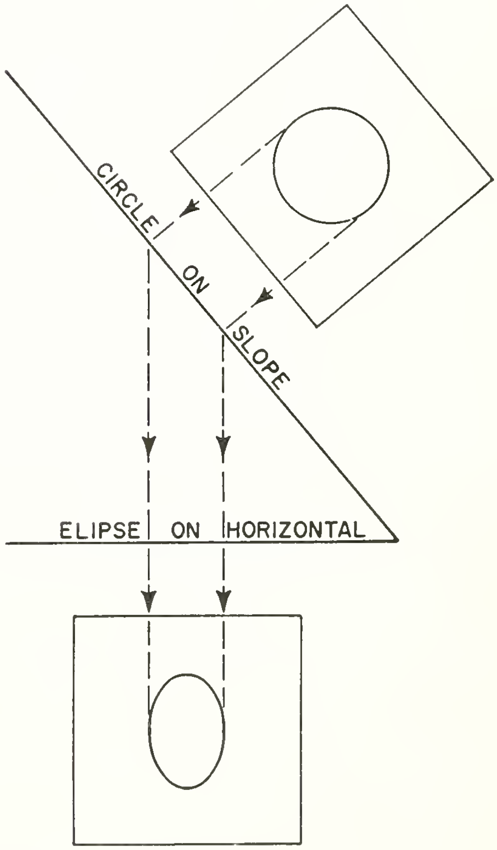


Figure 8.--The plot used in the simplified form of slope correction forms a circle on the slope. Its projection to the horizontal becomes an elipse.

FOREST FIRE

The Buckhead Fire

The Buckhead fire, one of the four largest in the Southeast in the last 2 years, burned nearly 110,000 acres in north Florida during the last week in March 1956. Approximately one-third of this acreage was on the Osceola National Forest. Probably as much as 90,000 acres of the final area was burned in a 10- or 12-hour period, starting shortly after 9:00 p. m. on the night of March 24. At the peak of its intensity, the rate of energy output of this fire was comparable to that of a summer thunderstorm.

Like the other three fires, as well as the Maine conflagration in 1947, the Buckhead was a cold front fire. Although these fires make their major runs during the passage of a dry cold front, their large size is due in part to severe burning conditions prior to the arrival of the front. During this earlier period the winds are usually in the quadrant between south and west, and the direction of spread is most likely to be in the quadrant between east and north. With the arrival of the cold front, the wind shifts rapidly to the northwest or north, thus causing the right flank of the original fire to form a number of high intensity heads which travel toward the south or southeast. In the case of the Buckhead fire, right flank became the head. The only exception to the typical pattern was that the frontal system was oriented such that the pre-frontal winds were in a west or slightly north of west direction and the wind eventually shifted to an east of north direction.

Probably the worst behavior characteristic of cold front fires is the long-distance spotting. In the Buckhead fire, embers were carried as much as 3 miles ahead of the main fire, although most of the spotting was $1\frac{1}{2}$ miles or less. At times ember showers within this distance produced firestorm effects by simultaneous ignition over extensive areas.

A conflagration potential had been established by drought conditions which had persisted for more than a year. A low water table in the swamps had made available large volumes of fuel, which in normal times would not burn.

Considering the drought, turbulence, and low-level jet winds, the behavior of the Buckhead fire was not a mystery. The behavior characteristics of this fire had shown up on previous large fires with similar conditions. For a period of 10 hours preceding the arrival of the cold front in north Florida, the low-level jet winds associated with the front were making their appearance in an area extending from northern Alabama to the upper Piedmont of South Carolina. The cold front was moving at a speed of about 25

miles per hour. Figure 9 shows the position of the front at 6-hour intervals from 1:30 a.m., March 24 to 1:30 a.m., March 25. Broken lines represent the estimated position of the front at 7:30 a.m. and 7:30 p.m. on March 24. This rapidly moving cold front started as a stationary front, the position of which is shown at 1:30 p.m. on March 23, when it extended across the northern part of the Central States.

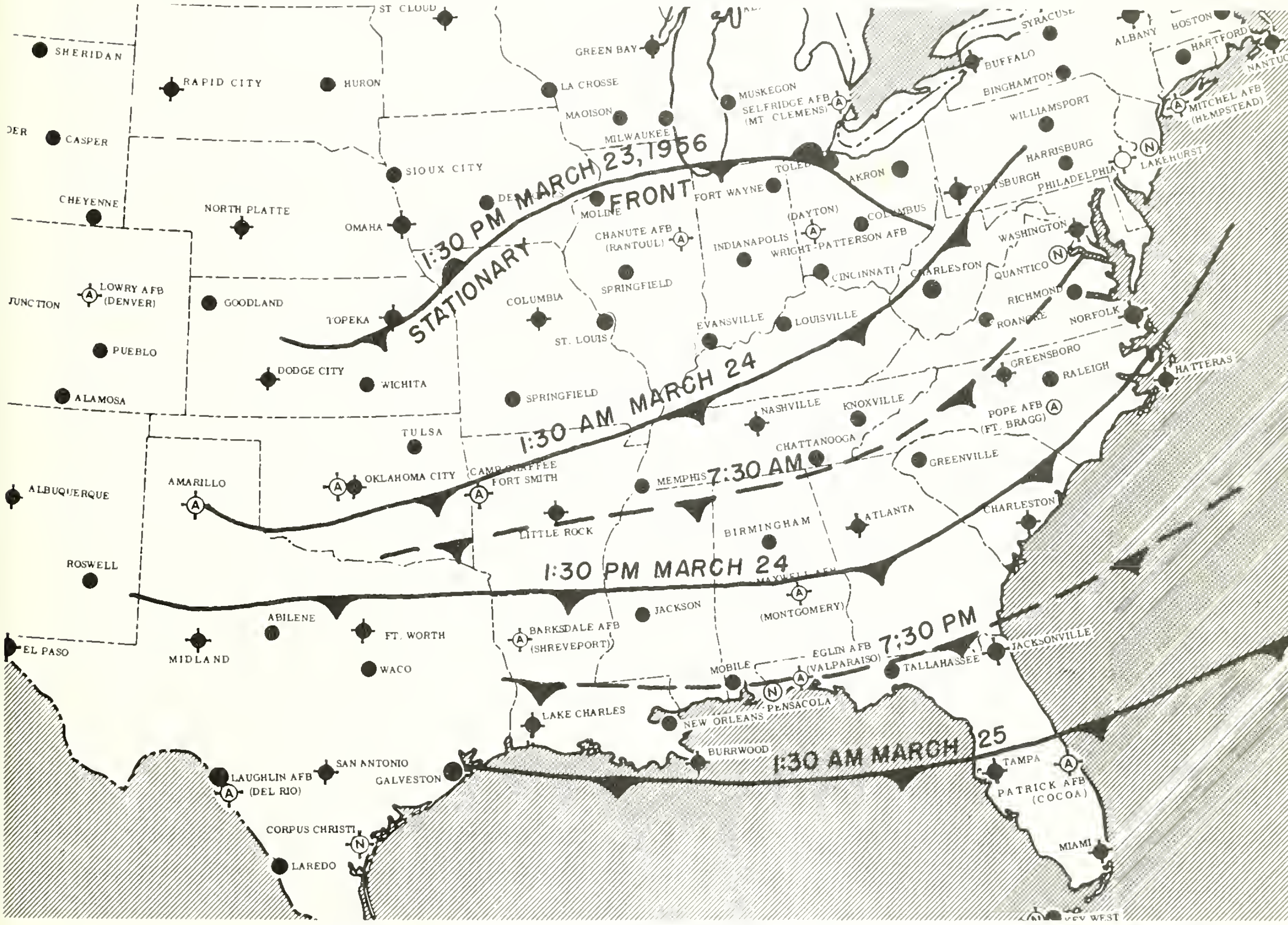


Figure 9.--Progressive southward movement of a cold front. Conditions accompanying this advance caused the Buckhead fire to spot 3 miles and make its biggest run. Even a few hours' warning of such conditions would be a major contribution to fire control.

The progressive southward movement of the dry cold front and corresponding southward movement of the severe atmospheric conditions associated with it illustrate what precision forecasts could contribute to fire control operations on a cold front fire. There were two periods in the course of this fire prior to the major blowup when knowledge of approaching turbulence and low-level jet winds would have brought into operation control measures which otherwise might not have been justified. Whether or not such measures would have stopped the fire's major run remains unknown, but the question itself points out the key role that precision forecasts could play when a conflagration potential exists.

Energy Studies

An important clue to the significance of certain atmospheric factors in the behavior of large fires was given by a thermodynamic analysis in 1953. This analysis indicated that factors most likely to control the behavior of large fires would be the same factors favoring strong convection over a large heat source. Work was continued in 1956 and has given an effective physical picture of a large fire in terms of its energy and energy transformation processes. Progress thus far contributes to the development of three important fields of work in fire behavior research and application. These are:

1. A classification of fuels in terms of expected fire behavior.--Basically, fire behavior may be regarded as an energy phenomenon controlled by the atmospheric and weather variables and the fuel variables. For the purposes of fuel classification, topography can be treated as a weather variable by introducing the concept of wind-slope equivalence.

Complex interacting relationships between variables in the two groups, as well as within each group, make an arbitrary approach to fuel classification in terms of fire behavior a very difficult problem. The use of an energy approach appears to be much more promising. Such an approach would use four basic fuel factors: (a) combustion period, (b) critical burn-out time, (c) available fuel energy, and (d) total fuel energy. This last factor is constant or nearly so for any given quantity of fuel per acre. The first three are variables which, even for any homogeneous component in a given fuel type, depend on factors such as moisture content and fire intensity. The combustion period may be defined briefly as the length of time required for a fuel to burn up completely, and depends primarily on fuel size, fuel arrangement, and fuel moisture. It may range from a few seconds for thin grass blades to several hours for heavy logs. Critical burn-out time is defined as the maximum length of time that a fuel can burn and still be able to feed its energy into the base of the forward traveling convection column; its magnitude depends primarily on the rate of a fire's energy output. The available fuel energy is that fraction of the total fuel energy which is fed into the base of the convection column. For fuels with a combustion period less than the critical burn-out time, the available fuel energy is equal to the total fuel energy. If the combustion period is longer than the critical burn-out time, the available fuel energy is less than the total fuel energy. Total fuel energy is determined by the quantity of fuel per unit area and combustion efficiency. If the combustion efficiency is assumed to be constant, the terms "available fuel energy" and "total fuel energy" can be replaced by the terms "available fuel" and "total fuel."

An example will illustrate how fire behavior relates to the four preceding quantities. Consider a fire spreading in an area of plentiful heterogeneous fuel, a considerable part of which is in the form of inflammable logs and heavy slash and the rest a mixture of smaller material such as twigs, pine needles, and grass. Assume that the critical burn-out time is about 20 minutes. Those fuel components with a combustion period less than 20 minutes will have an available fuel energy equal to their total fuel energy. However, logs and heavy limbs may require several hours to burn out, so their available fuel

energy may be very low; they could still be burning after the fire front had moved several miles but would not be affecting the behavior at the fire front. From the standpoint of fire behavior, a crown fire in a conifer stand could have more available energy than a fire in an area of heavy logging slash.

Much of the effect of fuel moisture has a simple interpretation in terms of the four basic fuel factors. Because moisture decreases the combustion rate, it increases the length of the combustion period. This in turn means that a smaller fraction of a heterogeneous fuel will have a combustion period less than the critical burn-out time. The available fuel energy and fire intensity will, therefore, drop as fuel moisture increases. For some fuel components a high moisture content produces an infinitely long combustion period; in other words, they do not burn.

A fifth fuel factor, the quantity of firebrand material available for spotting, is pretty much independent of the other four, but would be an essential factor in fuel classification.

2. The development of scaling laws for fire behavior.--Although it is doubtful if many of the behavior characteristics of large fires can be reproduced on a small scale, the thermodynamic analysis indicates that some phases of the convective process can be studied on scale-model fires. From the standpoint of energy rate relations, the scaling laws are comparatively simple. For example, in a neutrally stable atmosphere, a high intensity fire putting out 10,000 BTU's per second per foot of fire front and driven by a wind of 25 miles per hour could be scaled down to a wind tunnel fire putting out 1 BTU per second per foot of fire front. The corresponding scaled wind speed would be 1.16 miles per hour.

3. Establishing more clearly the relative priority of the problems in fire weather forecasting research.--The application of a large part of our fire behavior knowledge must come through the fire weather forecaster, who in turn must know which weather and atmospheric conditions control fire behavior. The effects of some weather factors, such as rain and relative humidity, are fairly obvious and well established. The effects of conditions of the upper air, such as winds aloft and turbulence, are not so obvious. Until now much of the evidence for the effect of the wind and temperature profiles on fire behavior has been of a statistical nature. However, analysis of the energy relations existing between a fire and the wind field in which it is burning makes it possible to illustrate quantitatively the significance of the wind and stability conditions aloft.

Curve W in figure 10A represents the rate of expenditure of energy in the wind field at 4:00 p.m. over Spartanburg, South Carolina, on March 30, 1953, when the Brasstown fire occurred. This high intensity fire traveled about 3 miles in $1\frac{1}{2}$ hours. The units are in horsepower per square foot and represent the rate at which wind energy streams through each square foot of a plane perpendicular to the wind direction. The energy rate values are shown as a function of height above the elevation of the fire. Curve F, the horizontal line, is the corresponding energy rate curve for the Brasstown fire.

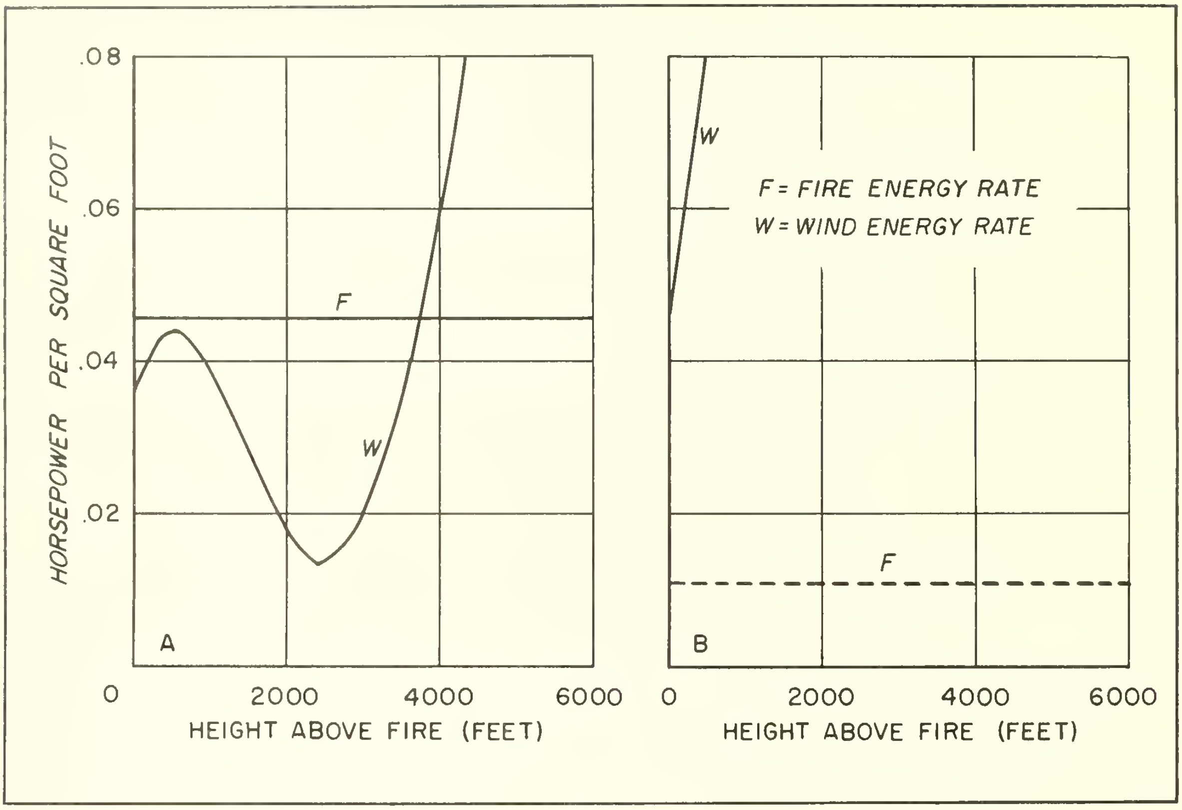


Figure 10.--The energy rates for a fire and the wind field in which it is burning are shown for two fires with different behavior characteristics. A, The two rates for a high-intensity blowup fire; B, The rates for a fairly intense fire driven by a strong wind.

It is also expressed in horsepower per square foot and represents the rate at which thermal energy was converted into turbulent energy per foot of fire front per foot of vertical rise in the convection column. Curve F is horizontal when the atmosphere is neutrally stable. If the atmosphere is unstable the curve slopes up very slightly. This means that the fire gains a small amount of energy from an unstable atmosphere.

Curve W was computed from the wind profile and air density profile. Curve F was computed for a rate of spread of 2.0 miles per hour and an estimated available fuel of 10 tons per acre. The most significant feature of figure 10A is the sharp drop in Curve W, which is caused by a zone of decreasing wind speed aloft. As a consequence, the rate of production of turbulent energy in the convection column above the fire greatly exceeds the corresponding energy rate in the wind field in a zone about 3,800 feet deep. The statement sometimes used by field men, "The fire wrote its own ticket," seems to have some meaning even in a physical sense. Near the surface the two energy rates are nearly equal. Above 3,800 feet the energy rate in the wind field exceeds that in the convection column.

Curve W in figure 10B shows the energy rate curve for the wind field at different heights above the surface over Charleston, South Carolina, at 4:00 p.m. on April 13, 1950. The rate of spread of the largest fire (715 acres) in this area on that day was not known, so the energy rate curve could not be computed. However, if the maximum rate of spread is assumed to be 0.4 mile per hour and the available fuel 12 tons per acre, then Curve F could be roughly approximated by the horizontal dotted line. The most significant feature of figure 10B is the very rapid climb of Curve W, which is caused by an increase of wind speed with height. With this type of an energy rate curve for the wind field, fires could be intense and fast spreading but should not develop the high intensity and extreme fire behavior characteristic of a blow-up such as the Brasstown fire.

Probably no accomplishment would contribute more to fire control operations than the development of methods for making precision forecasts of the atmospheric conditions which produce major fires. Effective application of our knowledge of the relation of weather to fire behavior depends heavily on such an accomplishment. Consequently, two research jobs take on a very high priority. First, is the determination of the causes of certain specific atmospheric conditions--especially the low-level jet winds. Second, is the development of methods for making precision forecasts of these conditions.

Georgia Fire Problem Analysis

Through a cooperative agreement between the Southeastern Station and the Georgia Forestry Commission, with funds provided by the Commission, a survey of forest fire problems and research needs in Georgia was completed by Dr. Kenneth P. Davis, of the University of Michigan School of Natural Resources.

The survey was stimulated in part by the large and devastating fires in late 1954 and in 1955 that balked suppression efforts. A second consideration was the probability that well-organized cooperative research could contribute much towards more effective fire control in the state.

Two reports of findings and research recommendations were prepared. The first is brief and illustrated; the second is a more comprehensive statement of specific studies that should be undertaken. Although the survey was confined to Georgia, most of the described problems and research needs are equally applicable to other southern states.

Number of Fires and Acres Burned Related to Burning Index

The combined data on number of fires and acres burned in 1955 for the seven states of the Northeastern Compact (New England and New York) indicate a direct relation to Burning Index, as shown in the following tabulation:

Range in Burning Index (Meter 8)	Total fires	Total acres	Fires per day	Acres per day
	Number			
0-10	729	1,181	4	6
11-20	448	1,873	13	40
25-40	878	2,660	35	99
45-80	1,818	8,363	73	343
85-160	1,197	12,508	150	1,490

The average number of fires per day roughly doubled as the Burning Index doubled. Thus, there was nearly a straight-line relationship between average daily occurrence and Burning Index. The increase in area burned per day is proportionately greater because of faster rates of spread and increased resistance to control on days of higher Burning Index. Such broad relations, which help to define the relative job load, should be extremely useful in fire control planning.

Wind Conversion

The majority of open-type fire danger stations in the South and East are located at fire towers to make use of the observers located there and because the towers provide handy mounts for the anemometers. The anemometer can be exposed to the free wind well above the rapidly growing vegetation, and the readings reduced by a suitable factor to the 20-foot standard. This arrangement obviates the necessity for frequent clearings required to keep the 20-foot standard anemometer operating properly. However, the advantage of the tower mount depends in part on an accurate conversion factor.

Such a factor was developed this year from a regression equation based on over 700 wind measurements taken at four widely separated standard danger stations--two in the longleaf-slash pine region and one each in Coastal North Carolina and Maryland. The equation is:

$$V_{20} = 0.154 + 0.732\ V_{50}$$

where:

V_{20} = wind velocity (m.p.h.) at 20 feet above the ground at the center of a clearing of radius approximately seven times the height of the surrounding vegetation.

V_{50} = wind velocity (m.p.h.) at approximately 50 feet above the surrounding vegetation canopy.

Since the intercept was small, it was ignored, and the result was the factor 0.732. The conversion table based on this factor has been in field use now for 5 months and has proven entirely satisfactory.

Testing the 8-100-0 Fire Danger Meter in the Longleaf-Slash Region

The 8-type fire danger meter was originally developed for the predominantly hardwood forests of the East, where it works very well. Since its introduction in 1954 the advantages of the new meter, particularly Build-up Index feature, have led to its partial adoption by most of the Southeastern and Southern States. Fire danger stations using the 8-type meter have been established there in hardwood and pine types similar to those in the East, and in pine types with lighter, grassy surface fuels such as the extensive longleaf-slash pine areas in the Atlantic and Gulf Coastal Plains.

From time to time fire control people have asked how well the 8-type meter works in the longleaf-slash pine type with its generally lighter and more flashy vegetation. Some feel that a meter specifically designed for rate of spread would better measure their job load. Also, they question whether the new meter is superior to the old longleaf-slash (rate of spread) meter developed in 1937 by the Southern Station and currently in use by many government and private fire control organizations in the Gulf Coast States. Others question whether any meter is of much use where the large percentage of incendiary fires makes the element of risk so variable. As far as is known, no actual tests have been made to answer these questions.

A study was established in 1955 in an effort to answer the questions: (1) does the 8-100-0 meter measure fire occurrence and acres burned per day in the longleaf-slash region with sufficient accuracy; and (2) is it superior on these two counts to the longleaf-slash meter? There were other minor objectives. Eleven key danger station locations were selected in six states throughout the longleaf-slash region from Georgia to Texas. An 8-100-0 station was installed at each, and at all locations but three a longleaf-slash station was also installed.

Records have now been kept for 1 year. Results to date for one representative station indicate that the 8-100-0 meter measures both fire occurrence and acres burned per day with good accuracy. The analysis is not far enough along to justify conclusions concerning the comparative accuracy of the 8-100-0 and longleaf-slash meters. The trend of number of fires in two counties as related to the Burning Index for Bulloch, Georgia, key station (fig. 11) is essentially linear, which is characteristic of other regions. The trend deviates from linearity on high index (above 80) days, which is not serious. It means only that if the linear trend is used for preparedness planning on high index days, the fire control organization would be expecting a worse situation than they normally get. The linear trend is desirable for ease in summarizing data for analysis reports. Scatter of individual data about the trend line is smaller than that observed for Region 7 data for the same period. This is very encouraging, since risk, which the scatter partly measures, is generally conceded to be more variable throughout the year in the South because of high incidence of incendiary fires. Twenty-six percent of the 184 fires in Bulloch and Candler Counties for the year were incendiary.

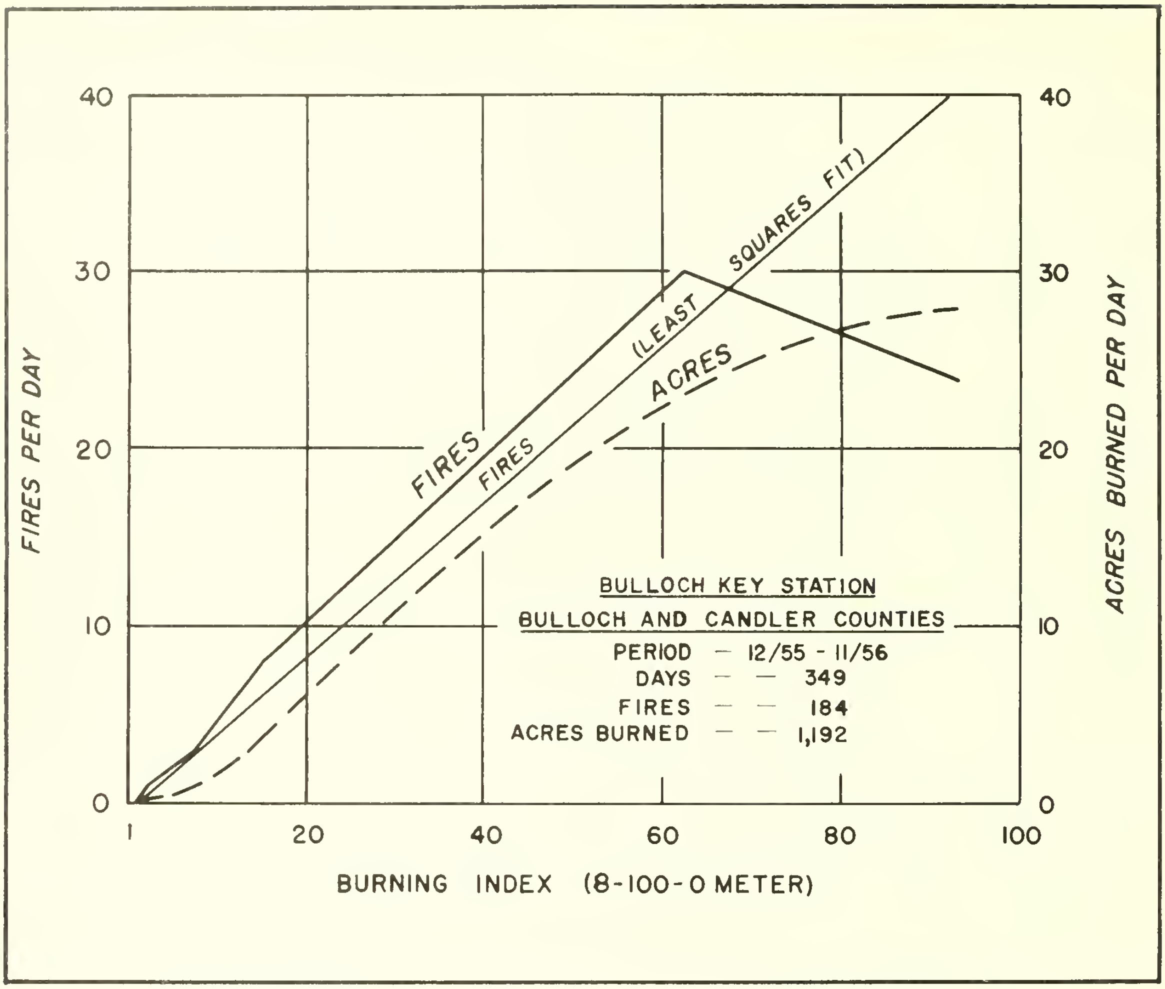


Figure 11.--Fires and acres burned per day in relation to Burning Index on the 8-100-0 meter, Bulloch and Candler Counties, Georgia.

The trend of acres burned per day as related to Burning Index is definitely curvilinear, which means that the acres burned per fire is increasing with increasing Burning Index. This also is characteristic of other regions and is so because fires spread faster and control is more difficult on high index days. Thus, it is reasonable to assume that Burning Index on the 8-100-0 meter is a fair indicator of rate of spread, since as stated before, the rate of spread and size of fire are greater on high index days.

WATERSHED MANAGEMENT

Integrated Management of Watershed Lands

Although studies of watershed deterioration have been featured at the Coweeta Hydrologic Laboratory, most of the current and planned investigations focus more on the basic hydrologic processes affecting water yields. One phase is use of two watershed units in a long-term test demonstration of integrated management for water and timber production. In a study of comparative water yields under two systems of management, a conversion cut was made in 1955 on paired Watersheds 40 and 41 as the first step in getting the timber stands ready for management.

Watershed 41, a 70-acre drainage, is to be handled for maximum economic returns from timber under a management system simulating that on national forest lands. In contrast, Watershed 40, totalling 50 acres, will be managed primarily for greatest yields of quality water consistent with some reasonable return from timber products. Principles developed in other Coweeta studies are to be used in planning and applying stand alteration practices that are best calculated to produce optimum yields of usable water.

Several improvement cuts over the next 15 to 20 years will probably be required to put the present stands in a manageable condition; and in the meantime, careful records will be kept of water yields and quality. In setting up the experiment on Watersheds 40 and 41, layout of logging roads and trails received particular attention as a key factor in keeping overland flow and stream siltation to a minimum.

Generally speaking, the logging plan for the two watersheds provides for a single climbing haul road, with secondary roads and skid trails held to the contour as nearly as possible. Logs are skidded uphill to the contour roads by power equipment. Roads are planned well in advance and laid out in winter when visibility is better for selection of grades and routes. Of paramount importance is the procedure for keeping roads and trails as far as practicable from drainage courses and streams, rather than building them up the main drainage and using tributaries for skid trails as is commonly practiced.

In constructing contour roads on the Coweeta watersheds, particular attention was given to the inside cut slopes. These were kept as shallow as possible and left vertical by the dozer blade. When so built, loose talus deposits soon form along the base of the cuts, affording better soil for plant establishment than the raw material exposed on a sloping cut. Usually the

Figure 12.--This mountain logging road has been seeded down with oats and perennial ryegrass to prevent gullying and erosion. View after one growing season.

overlying mat of roots and organic matter helps protect the upper edge of the cut, and natural vegetation creeping up the talus slope will eventually close with it, thus providing effective slope stabilization at minimum cost.

Another feature in constructing these logging roads is to put in plenty of broad-based water bars at frequent intervals. These are formed by making a wide shallow sweep with the dozer blade, and it is important that they be left in good operating condition at the end of each logging job. It is also advisable to seed in skid trails and contour roads immediately after the area served by the road has been logged (fig. 12). Quick protection was afforded the Coweeta roads by seeding oats under-planted with perennial ryegrass--the latter providing more permanent cover under tree shade.

The first improvement cut on Watersheds 40 and 41 was accomplished without any impairment of water quality, thus demonstrating that a properly laid out system of climbing and contour roads can be used in the Southern Appalachians to remove wood products with no appreciable disturbance to soil.

To further explore the possibilities, pilot demonstrations featuring good location and layout of logging roads are being installed on two large-scale, timber sales. One on the Chattahoochee National Forest in North Georgia is already under way, with logging by a private operator under a special contract with the Forest Service. A similar pilot sale is being negotiated on the George Washington National Forest in Virginia to supplement Southern Appalachian experience in a mountain area of lower rainfall. Coweeta personnel are helping plan and install these demonstrations and will participate actively in the follow-up observations and appraisal of results.

Figure 13.--Water quality is not impaired when logs are skidded uphill to roads laid out on proper grades and located away from natural watercourses.

Experience in the pilot study on the Chattahoochee has already shown need for modifying road layout specifications to fit the lay of the land. Stamp Creek, where the sale is in progress, is a long, narrow drainage enclosed by gradually climbing ridges. An access road not exceeding a 10-percent grade has been built combining the climbing and contour principles in one road, thus eliminating need for contour spurs. The bulk of the area is being logged uphill to this road, most of which is located about two-thirds of the distance up the ridge from the main stream (fig. 13). Some small timber is being skidded downhill to the haul road but following the ridges rather than the hollows. Skid trails are provided with water bars as soon as all logs are removed. Two of the eight operating units in this sale have already been logged; but there has been no visible movement of soil into streams, turbidities as measured at the mouth of the watershed have not increased, and damage to the forest floor seems negligible.

These demonstrations and the long term pilot test of management systems will be of interest to many foresters and loggers. Groups of citizens concerned with municipal water supply continue to visit Coweeta for advice on multiple-use management of their watersheds. The queston commonly posed by these groups is, "How can we harvest timber from our watersheds without damaging water quality?" Demonstration watersheds help show them that it can be done. It usually is necessary to point out, however, that the best-planned logging layout will not of itself assure minimum damage to water values, since much depends on how well the operation is supervised and carried out, including adequate protective measures when it is closed down.

Effect of Land Treatment on Water Use and Behavior

Bare soils in the Piedmont generally have much lower infiltration rates than those with plant cover because baking from intense summer heat and soil movement with subsequent sealing of surface pores greatly reduce their water intake. Thus, vegetation, by providing a protective mantle, minimizes the detrimental effects of climatic extremes and of destructive overland flows. It also maintains conditions favorable for soil flora and fauna which help build fertile permeable soils that absorb water rapidly.

During winter months most of the Piedmont soils have taken up large quantities of water and are near field capacity. Under a young pine plantation, there is rapid withdrawal of water during the growing season from evaporation and transpiration. But from a bare soil--comparable in slope, topography and aspect--the moisture loss is from evaporation only. This accounts for the much greater removal of water from a pine stand than from a bare site, as shown in a recently completed study (fig. 14).

Such differences in water removal are of considerable practical significance and demonstrate that timber stands, by using up substantial quantities of water, provide for maximum intake and storage of subsequent rainfall, thereby minimizing damaging runoff and erosion.

Bare clay Piedmont soils become sealed at the surface so that the intake of water is very slow and often produce great quantities of sediment-laden runoff even during minor storms. However, when such a site is stabilized with vegetation, raindrop impact is absorbed by the organic ground cover and surface intake of water much improved. This is documented by runoff measurements from a small watershed consisting of about 7 acres of pine plantation and 4 acres of barren, eroding soil. In 1955 the gullied area was smoothed, fertilized, and planted with sericea lespedeza and crotalaria with results pictured in last year's annual report. Figure 15 shows the regulating effect on runoff for a storm occurring a few months after treatment, as constrasted with one of comparable amount, intensity, duration, and antecedent soil moisture prior to stabilization. In both instances, zero on the graph represents the time precipitation began, and the start of runoff is indicated on the horizontal scale of the storm hydrograph. It will be noted that after stabilization there was a lag of about 20 minutes in the time required for overland flow to begin, and the stormflow was not only greatly reduced but spread out over a longer period. With more of the water seeping into the soil there was a reduction of 74 percent in peak discharge and 49 percent in total discharge from the storm. Erosion was reduced to practically nil.

Land use in the Piedmont, both good and poor, obviously has profound effects on the water resource and hence merits increasing attention in programs for water use and control. Through research we can perhaps learn how to manage timberlands more effectively for control of damaging flows without subtracting prohibitively from water yields.

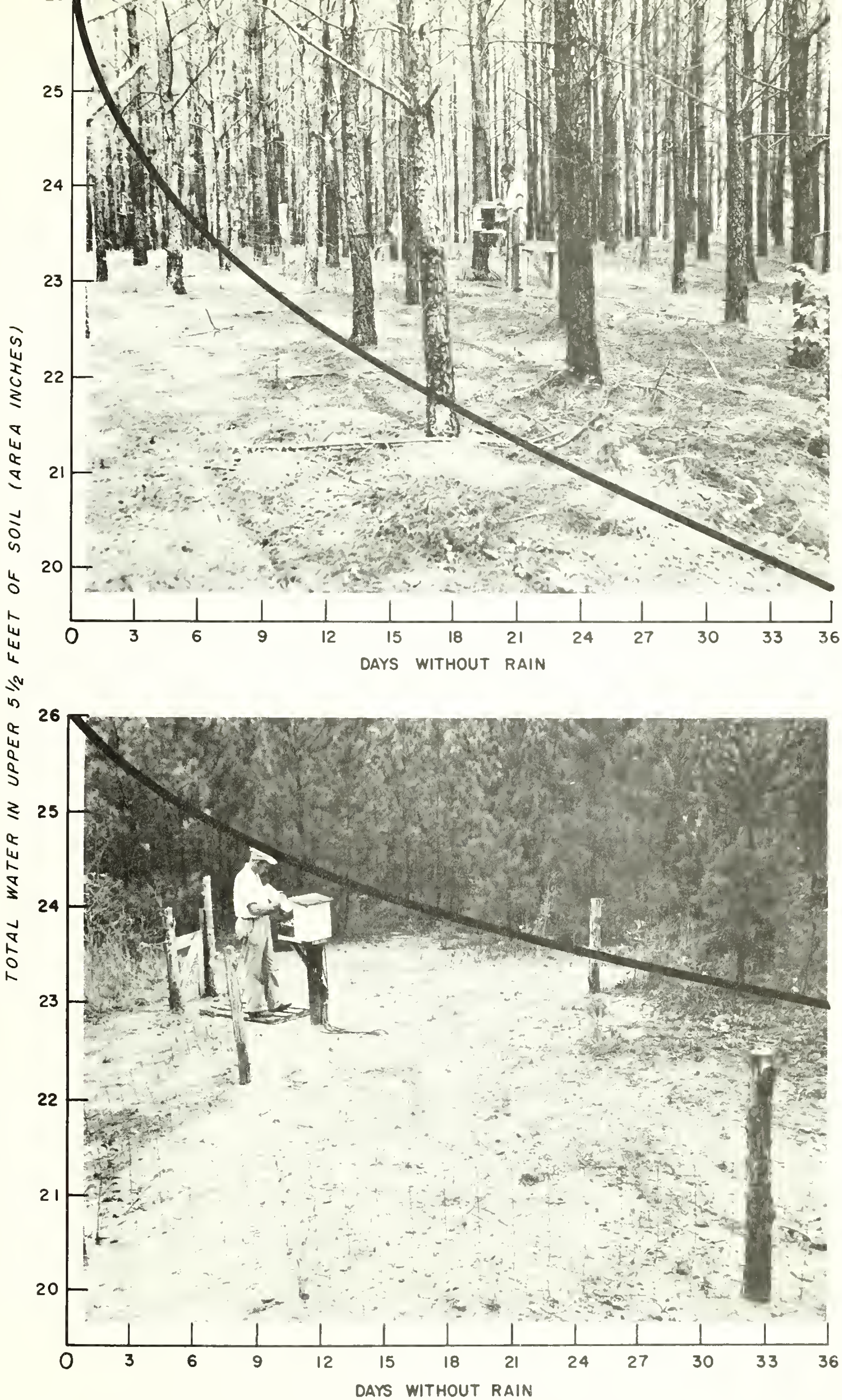


Figure 14.--Measured water loss during a dry period was twice as great from a pine stand (above) as from a barren area (below). In addition to having a faster intake rate, the pine soil has more storage space for future rains, thereby reducing runoff.

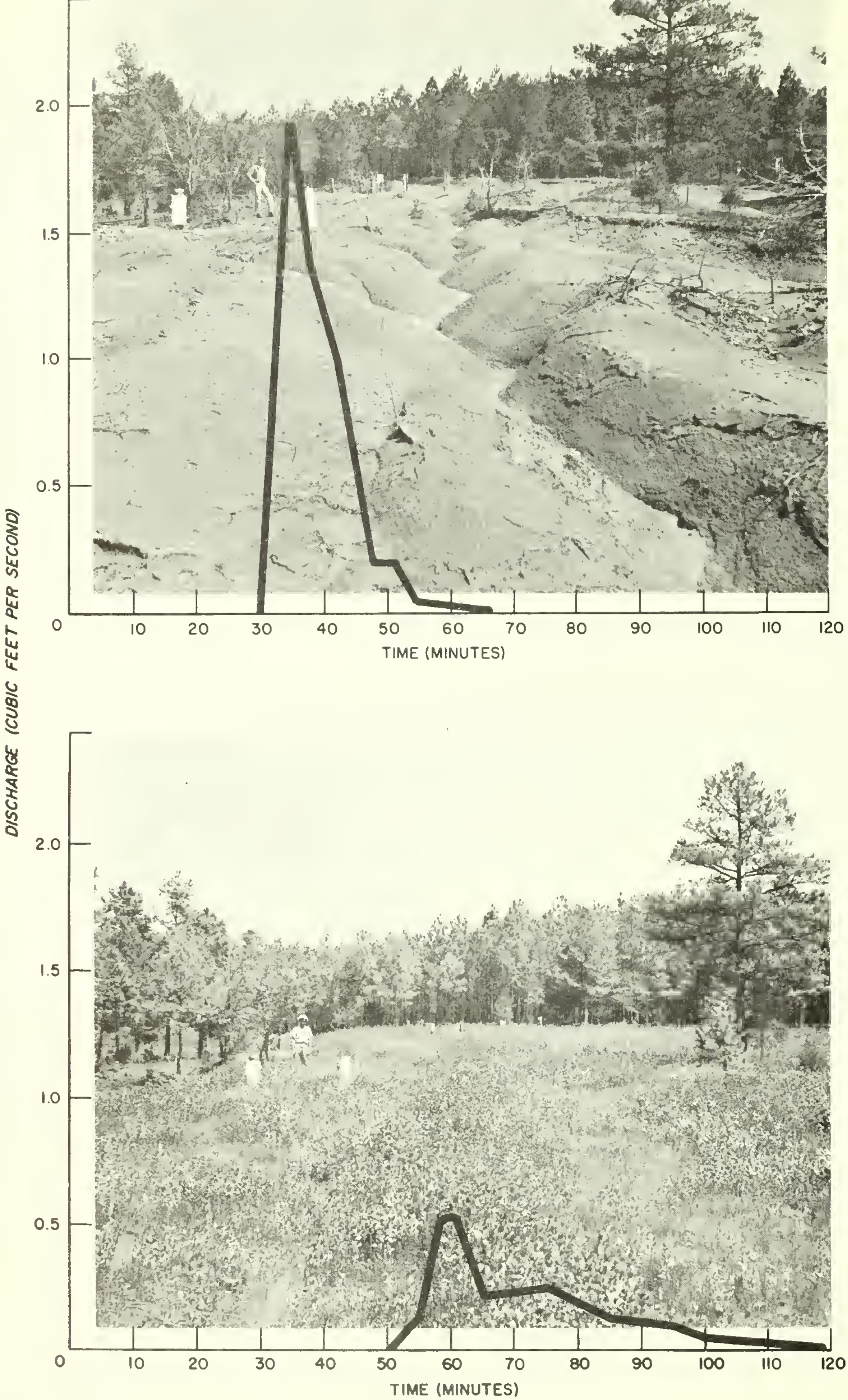


Figure 15.--Large areas of the Piedmont are in the condition shown in the upper photo. A cover crop on the same area, shown below, reduced peak flow 74 percent and considerably delayed storm runoff.

FOREST UTILIZATION

Expansion of forest utilization work in the Southeast brought expanded cooperative research with universities, colleges, and industry; increased research by Station personnel; and greater service work. The latter included on-the-ground assistance to forest products industries, short courses in sawmilling and kiln drying, industrial surveys on pallet manufacturing and particle board manufacture, and investigations of raw-material supply for new enterprises.

Log and Tree Quality Studies

In cooperation with the Southern Forest Experiment Station and Region 8 of the Forest Service, the project on southern pine log and tree grades has been greatly speeded up, with a full-time project leader conducting log and tree grade studies in Arkansas, Mississippi, and Florida. Field work on second-growth and old-growth shortleaf pine in the Ouachita National Forest in Arkansas was completed with a study of 182 trees which bucked into 529 logs. After trees and logs had been diagrammed (fig. 16), grade-yield data were obtained on green and kiln dried lumber cut from the logs. Field work on 124 loblolly pine trees in Mississippi was also completed during the calendar year, but the sawmill phase will not be completed until calendar year 1957. Additional studies in early 1957 will cover a good sample of longleaf and slash pine in Florida. These data, with previously collected data on loblolly and shortleaf pine in South Carolina and Georgia, will be completely analyzed by statistical methods for development of acceptable log and tree grades.

Figure 16.--Each tree and each log was completely diagrammed for location of visible defects before being sawed into lumber as part of the pine log and tree grade studies.

Cooperative work is continuing with N. C. State College in the development of hardwood veneer log grades. Previous work under this program included the development of a sampling technique to determine the percentage of clear veneer from a given short bolt and an analysis of bolt characteristics and how they affect the yield of clear veneer obtained. The analysis described the effect of four factors: (1) bolt diameter, (2) width of clear cutting, (3) length of clear cutting, and (4) outside appearance of the bolt upon the yield of clear veneer. Further studies during the year determined the relationship between the yield of clear veneer cuttings (defect clipped out) from long bolts versus short bolts, and a field analysis of four different grading systems was made to find whether any one system more clearly defined yield levels. The four systems investigated worked well in defining yield levels but no one system was superior to the others. None of the systems adequately defined yields from completely clear veneer logs. Additional work is necessary on this project to develop veneer log grades suitable for use in research and industry.

Charcoal Studies

A new 7-cord charcoal kiln was constructed at the Athens Research Center and 13 runs were made in this equipment during the calendar year. Half of the new kiln is constructed with a double wall with the inner space filled with sand and the other half is single-wall construction with reinforcement rods. The double-wall construction requires less maintenance because of the outer seal, but neither type of construction has suffered any serious deterioration as yet. In addition to the accumulation of much worthwhile information on charcoal yields, quality of charcoal, and method of operation, two important contributions were made through the charcoal research at Athens.

The first was the development of the open-door method of firing the kiln, which involves the ignition of the charge with no control over the amount of air available (fig. 17). This open firing continues for only a fraction of an hour and results in uniform ignition difficult to obtain by the old method of closed-door ignition.

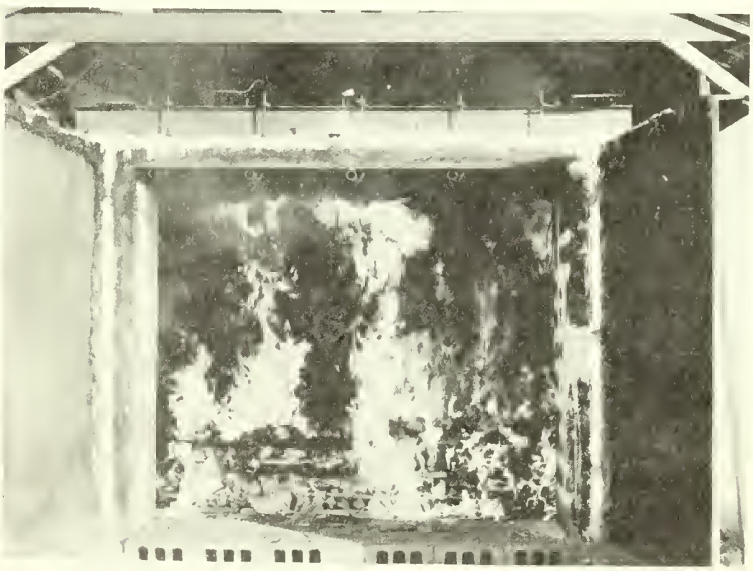


Figure 17.--The open-door method of firing a charcoal kiln results in even ignition and reduced coaling time.

Second was the development of an inexpensive standard brand microammeter to measure charcoal kiln temperatures (fig. 18). This instrument was calibrated to suit charcoaling conditions and tested in a number of kiln runs. Good temperature comparisons were obtained between this inexpensive instrument and an accurate temperature-compensating potentiometer, thus indicating that simple-to-operate, inexpensive equipment can be used to provide scientific methods for producing charcoal of good quality.

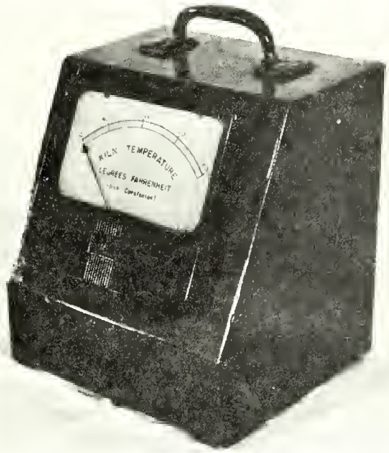


Figure 18.--This low-cost microammeter was developed and calibrated for charcoal kiln temperatures and permits positive control of kiln conditions.

In cooperation with the N. C. Department of Conservation and Development, comparative studies were made of three different type charcoal kilns at Bladen Lakes State Forest near Elizabethtown, N. C. Kiln types included in this study were the $\frac{1}{2}$-cord metal beehive-type kiln, the $1\frac{1}{2}$-cord metal beehive-type kiln, and the Forest Products Laboratory-designed 2-cord cinder block kiln. Although the data have not been completely analyzed, preliminary analysis shows that the 2-cord cinder block kiln produced a charcoal yield of 32 percent of the ovendry weight of the wood, the $\frac{1}{2}$-cord metal kiln produced 27 percent, and the $1\frac{1}{2}$-cord metal kiln produced 22 percent. The time required for the operation of each type kiln was obtained and a report currently being prepared will reveal the actual cost per ton of charcoal produced by each of the kiln types and other relevant information. For a comparison of the yield figures given above, the 7-cord Athens kiln in 9 runs consumed 142,155 pounds of wood (ovendry weight), and produced 48,276 pounds of charcoal, providing a yield of 34.0 percent.

Seasoning Studies

A study was made of 24 air seasoning yards in Georgia to determine current practices being used. Information was collected on the time required to dry lumber of different species and thicknesses, the amount of seasoning degrade and type that occurs with different types of seasoning, and current practices. There are five types of air seasoning stacks used in Georgia: the crib pile, the flat pile, the package pile, the end pile, and the end rack (fig. 19). The results show that air seasoning practices in Georgia are not generally good and that some yards have degrade of more than 40 percent of the value of the lumber. Very few lumber yards in Georgia use roof covers on their seasoning piles; this results in a considerable amount of degrade in

the upper layers of lumber. Other poor practices include inadequate space between piles, improper stickering of the lumber, poor yard sanitation with debris and weeds cutting off air circulation, and improper piling to protect the ends of the lumber. Several reports are being prepared on this study. Flip charts showing good practices to be followed in air seasoning have been drawn up and shown to groups of Georgia lumbermen.

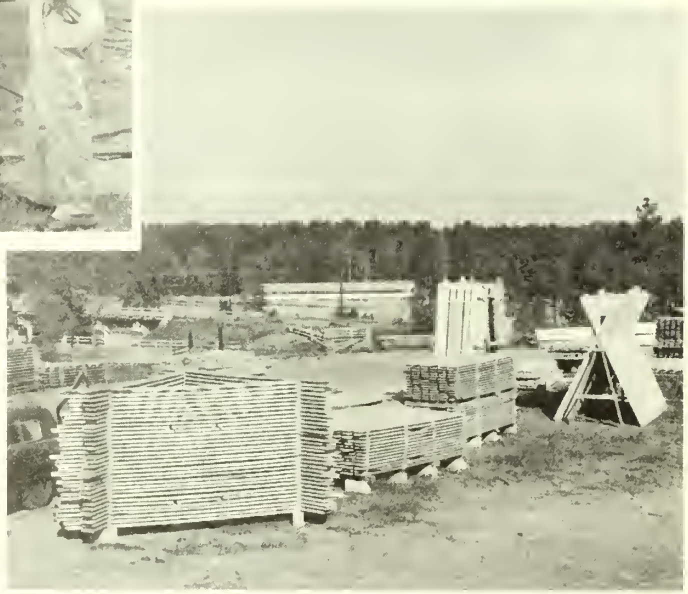


Figure 19.--At right, five methods of piling: crib, flat, package, end, and rack. Above, measuring moisture content and seasoning degrade at different elevations in end-piled lumber.

To obtain more detailed information on the rate of seasoning by different piling methods, a second study was undertaken involving the five piling methods mentioned above and the checking of moisture content once a week until it reached 18 percent or below. In this one study the rate of drying was most rapid for the end rack, which dried from the green condition to 18 percent moisture content in less than 2 weeks, and slowest for the end pile, which took 28 days to dry to 18 percent moisture content. A further analysis of the data and replications of the study will reveal more specific information on drying rates and degrade, by stacking methods.

A great deal of stain, warp, and checking occur during the air drying process. In trying to reduce this degrade as well as drying time, some companies have attempted to predry lumber in various types and shapes of

buildings where the air circulation could be increased by means of fans; usually, little or no heat is employed. In an effort to study this problem, a research project was started at the Athens Research Center in which 1-inch lumber of southern pine, yellow-poplar, and other hardwoods could be dried at various rates of circulation, but with all other variables held constant. Modifications have been made in the modern dry kiln to permit air circulation rates through the layers of lumber of 150 feet per minute, 500 feet per minute, and 1000 feet per minute. A number of such runs will be made with the temperature held at about 80° F. The lumber will be graded before and after drying to develop data on the economics as well as the drying rate. At the same time the lumber is being dried experimentally in the dry kiln, matched piles of lumber are being dried on an air seasoning yard under standard conditions. Two loads of rough green 4/4 lumber have been predried at an air velocity of approximately 165 feet per minute. The first load, yellow-poplar (fig. 20), was predried to 18 percent moisture content in 17 days without significant change in grade. The companion load of yellow-poplar, air seasoned on the cooperating lumber company's yard, required 32 days to dry to 18 percent moisture content under favorable weather conditions. No significant change in grade occurred in the yard-seasoned load. A second load, sap gum, was predried to 18 percent moisture content in 13 days without change in grade. The companion load on the lumber company's yard was still not dry 6 weeks after piling.

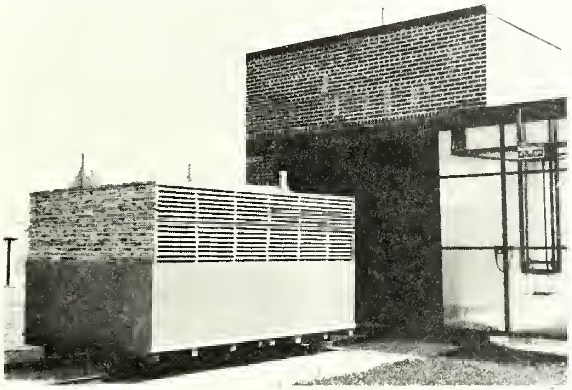


Figure 20.--Yellow-poplar to be predried in the Athens research kiln.

When sufficient lumber of different species has been predried to determine the optimum air velocity in keeping with lumber degrade and cost, the next step in this study will be to design a structure that will reproduce these conditions at the lowest possible cost.

A cooperative study was completed with Duke University involving the kiln drying of red and white oak treated with urea crystals and a commercial salt with a corrosion inhibitor. Following seven kiln runs, the following results were obtained: (a) For bolt treatments the red oak developed more degrade than the white oak lumber, (b) lumber treated with the commercial salt degraded less than that treated with crystal urea, (c) a straight noncyclic schedule for drying can be used, (d) better results were obtained when the chemical was applied to the boards in solid form and bulk piled than when the boards were dipped in a salt solution, and (e) white oak boards treated with commercial salt as a dry spread can be kiln dried from a green condition to 8 or 9 percent in 10 days without excessive seasoning defect.

Salt-treated material caused corrosion problems in kiln equipment, and this disadvantage needs further investigation. Future studies will involve mechanical testing of wood kiln dried after salt treatment to determine changes, if any, in strength properties.

Hickory Task Force

Three new Hickory Task Force Reports, Numbers 3, 4, and 5 (see list of publications at the end of this Report), were printed and distributed during the year, and an additional four manuscripts have been submitted for review. Interest in finding profitable uses for hickory continues at a high level. One of the most promising is railroad cross ties. Following the survey of 1953, a resurvey in 1956 showed that although only about 12 railroads out of 60 are now accepting hickory cross ties, the number of hickory ties being purchased has increased something like 5 times, and the railroads are satisfied with their performance both as to treatability and service in the tracks. A talk before the Railway Tie Association stepped up the interest, and a number of railroads not using hickory are now investigating this source of supply.

The second largest potential for hickory is the pulpwood industry. It has been shown that hickory makes a satisfactory pulp for many types of papers, and a few pulp companies are buying and using hickory veneer cores. The only major objection to hickory from pulp companies using hardwoods is that they cannot get the bark off in their conventional barking drums. New debarking equipment may overcome this difficulty and open the door for much wider use of this abundant species.

Buying Pulpwood by Weight

A number of pulp companies have begun purchasing pulpwood on a weight basis, since this method appears to have advantages over the old system of purchasing on a cord or unit basis. In cooperation with the Forest Products Laboratory, a review of literature and research data was made to compare the measurement of pulpwood by volume and weight. A number of pulp companies were also requested to supply their data on weight-volume relationships. This study points out that purchase by volume measurement was very erratic because the content of a cord may vary from 50 to 100 cubic feet because of differences in size of stick, length, species, and other factors. Also, variations in moisture content and density of wood make it difficult to relate volume to weight. The weight of any given volume of wood can be determined rather accurately if the density and the moisture content of the wood are known. It also points out that the weights being used by pulp companies are very close to computed weights based on average density and moisture content values of the species being purchased (fig. 21). This study, published as a Station Paper, concludes that no single factor will serve all existing variables encountered in measuring wood by weight or volume, and lists several advantages of measuring wood by weight. Methods are needed for direct field determination of weight without the necessity of conversion to volume estimates.

Low-Grade Hardwood Paneling

A variety of hardwood paneling was made by workers at the Athens Research Center, employing unusual methods such as steel brushing, sand blasting, and modernistic finishing methods on very low-grade (No. 3 common)

oak, hickory, and a few other species. Samples were displayed at the national meeting of the Forest Products Research Society, and a public poll was run during this meeting to determine customer preference of the different types of paneling. A number of hardwood paneling manufacturers are interested.

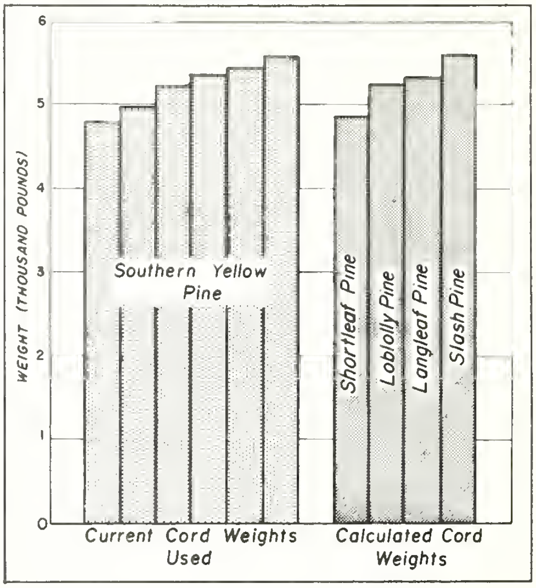


Figure 21.--A comparison of cord weights used by pulp companies, and calculated weights based on average specific gravity, average moisture content, and a cord volume of 72 cu. ft.

Paper-Faced Lumber

In cooperation with the Forest Products Laboratory, tests have been made on low-grade oak and hickory faced with resin impregnated paper. This covering serves to mask defects, improve dimensional stability, and provide a better surface for paints. Samples have been put under weathering tests at Madison, Wisconsin, and Athens, Georgia, and other service tests are being developed. At the Athens Research Center a 10x10 storage house has boards and battens of paper-faced lumber on one side, and paper-faced lap siding on the other (fig. 22). Part is unpainted, part painted, part backed by building paper, and part unbacked. This exposure test should demonstrate advantages and disadvantages of the material.

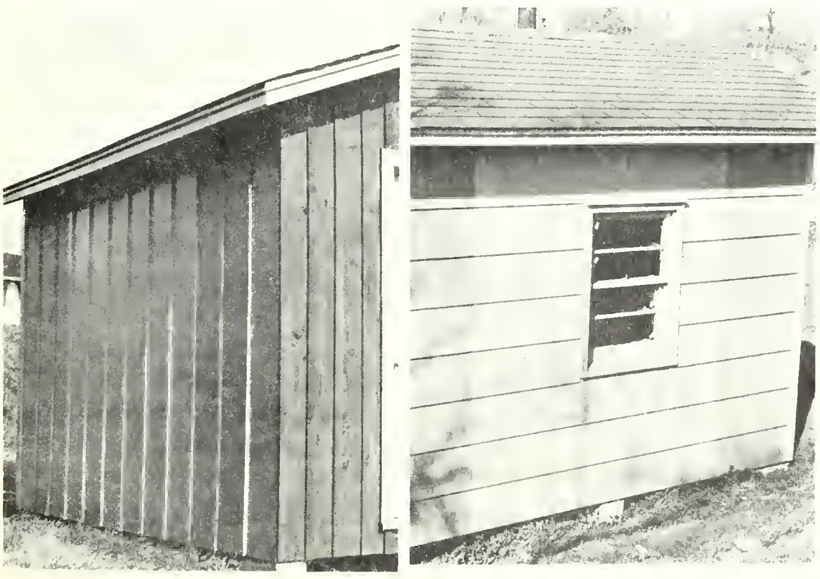


Figure 22.--A test at Athens, Georgia, of low-grade hardwood lumber faced with resin-impregnated paper. Left, board and batten; right, lap siding.

FOREST DISEASES

Oak Wilt

In studies on the epidemiology of oak wilt in eastern Tennessee and western North Carolina over the past 6 years, about 250 wilt centers have been found in 14 counties in Tennessee and 4 in North Carolina. One-fourth of the centers found from 1951 to 1955 were active in 1956. The oldest centers known originated about 1945, and averaged 0.4 acre in extent, with 21 dead or dying trees each when found.

Forty-six percent of 52 centers observed for 3 or more years became inactive naturally. At active centers, an average of two trees per year died of wilt. No centers inactive for 3 years were found to resume activity. Only 2 percent of the 494 wilting oaks found during 1954-1956 were white oaks.

Tests involving the copper sulfate poisoning of 40 healthy red and white oaks surrounded by other oaks showed 7 trees to be grafted to 6 of the poisoned trees (fig. 23). In three cases the grafts were between white and red oaks.

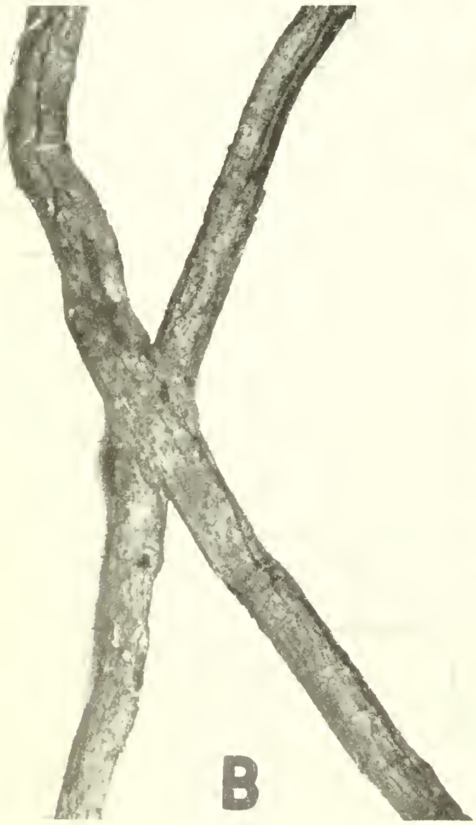


Figure 23.--A, A red oak defoliated by copper sulfate uptake through root graft connection with root of poisoned stump. Photo four weeks after poisoning in mid-August. B, A graft of two red oak roots that transmitted enough copper sulfate from a poisoned stump to the adjacent tree to kill the latter. The squares are two inches on a side.

Ninety-six percent of the newly wilted trees found in 1956 were less than 50 feet from previously infected trees.

Control measures conducted by the State forest services of Tennessee and North Carolina, involving summer felling of wilt trees, ammating the stump, and spraying the trunk and limbs with a BHC-chlorinated-phenol spray, appear to have reduced wilt incidence in intensively studied counties. In Greene County, Tennessee, there was a 75 percent drop in new wilt cases this year, following control measures instituted in 1955. In the Buncombe-Haywood-County area of North Carolina, there was a 67 percent drop in new cases the year following control instituted in 1954.

In Tennessee and North Carolina, wilt has been increasing at a slow rate, and the survey and control efforts of these States supplemented by surveys, cultural diagnosis, and technical assistance of this experiment station seem to be aiding in checking the disease. The above account does not deal with the oak wilt situation in the other Appalachian States, since intensive studies have been confined to areas in North Carolina and Tennessee.

Littleleaf Disease of Pine

Earlier work with salts of 14 elements applied as soil amendments showed a high degree of prevention and recovery from littleleaf in shortleaf pine only where nitrogen was added in large amounts. New results of foliar analyses on 32 fertilized shortleaf pine plots showed that the littleleaf trees, before fertilization, averaged only 78 percent of normal in nitrogen content, and that the nitrogen treatments brought them to normal in 1 year, thus explaining the recovery of many of these trees. Healthy trees had above-normal nitrogen in the needles after treatment, thus explaining the low incidence of littleleaf in these trees subsequent to treatment. The nitrogen treatments, all of which raised foliar nitrogen, involved the addition of either ammonium sulfate at 1,600 pounds per acre, nitrate of soda at 2,000 pounds per acre, or milorganite at 5,000 pounds per acre. Plots to which gypsum, muriate of potash, or leafmold were added showed no increase in foliar nitrogen.

The annual felling of shortleaf pines with littleleaf on a 1,000-acre tract in South Carolina between 1944 and 1954 resulted in a somewhat lower incidence of the disease than on a neighboring check area. However, by 1956, 40 percent of the original plot trees on the "eradicated" area and 53 percent of the plot trees on the check area had become diseased. The slight apparent benefit from treatment may well have been due to thinning or soil effects, and was not great enough to indicate that annual felling of littleleaf trees is an effective or feasible control measure. Salvage of such trees before they die is wise where practicable, but should not be considered a control measure.

The first test of shortleaf pine progeny from open-pollinated trees exhibiting apparent resistance to littleleaf against *Phytophthora cinnamomi* inoculation produced 55 percent resistant seedlings as compared with 32 percent resistant among progeny from littleleaf trees. The 64 resistant progeny selected from this test have been outplanted in a littleleaf area.

A second larger test involving 790 seedlings, including those from selfed, cross- and open-pollinated "resistant" parents, already shows great differences in growth and top symptoms, but the seedlings have not yet been dug for root evaluation. The current tests are conducted in large concrete tanks, inoculated and frequently heavily watered (fig. 24).

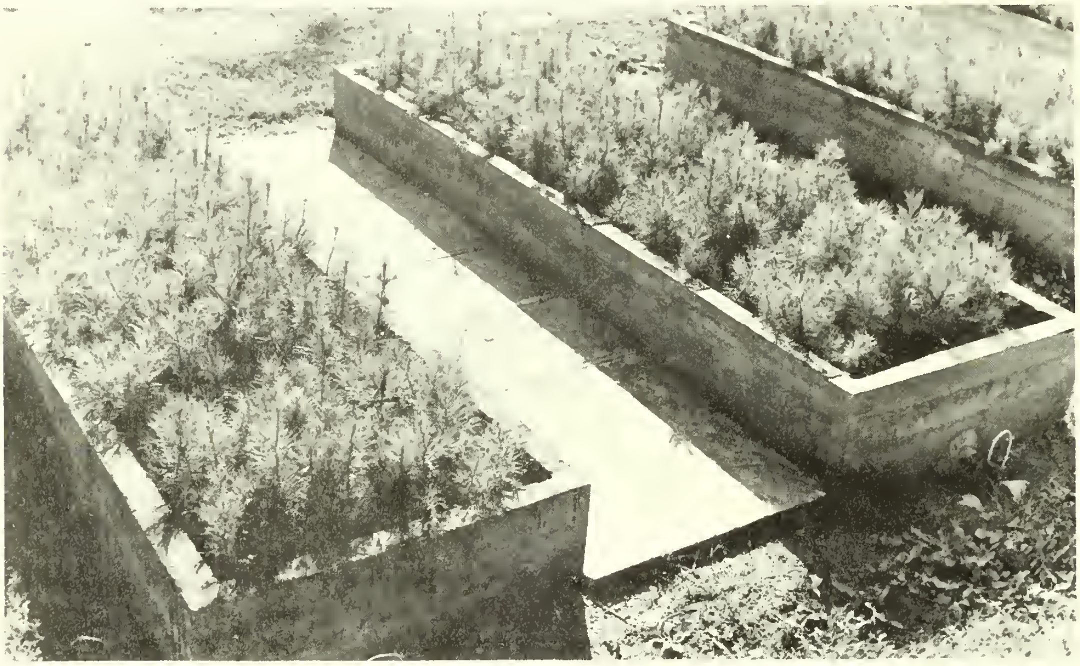


Figure 24.--Progeny from selected shortleaf pine undergoing littleleaf resistance test. Soil is a clay from nearby littleleaf area, inoculated with Phytophthora cinnamomi. Watertight concrete tanks are flooded twice a week during growing season.

Shortleaf and loblolly pines showing what appears to be strong resistance to littleleaf are continuing to be sought, and scions from them are grafted at the Athens seed orchard for later use in breeding.

Unlike grafting, the rooting of cuttings establishes a shoot on its own root system. This has advantages in a selection and breeding program for littleleaf resistance. Shortleaf and loblolly pine seedlings $2\frac{1}{2}$-years-old were successfully air-layered, producing good root systems, but air-layering was unsuccessful on shortleaf shoots from a tree grafted 8 years before with scions from adult trees. A method was also developed for successfully air-layering shortleaf pine needle fascicles.

Nursery Diseases

Excellent control in Georgia nurseries of a black root rot (fig. 25) in southern pine seedlings, and also good control of weeds, was obtained with methyl bromide at 1 pound per 150 square feet (290 pounds per acre) at a cost of about $200 per acre for material plus $200 for labor. Good but more uneven results, which can probably be improved upon with more knowledge of methods of application, were obtained with Vapam at 50 gallons per acre bled into the sprinkler line. The material cost for the Vapam was $150 per acre and the labor cost negligible.

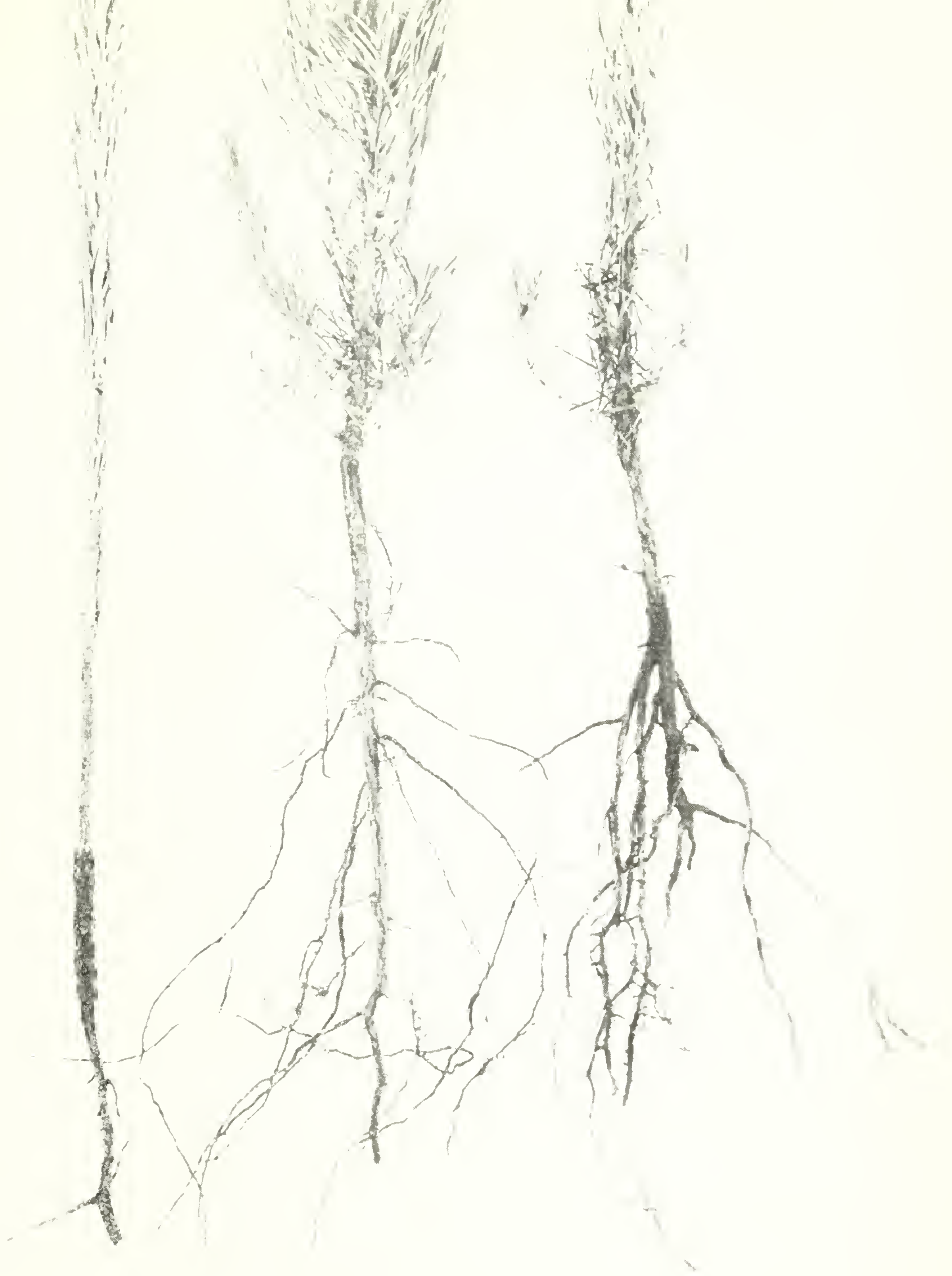


Figure 25.--Black root rot attacking slash pine nursery stock. The middle seedling shows a healthy root. The one on the left shows extreme root damage with the characteristic thickened area. The one on the right shows recovery following killing of the tap root with involvement of the replacement roots.

Surveys of 32 southern nurseries for nematodes disclosed nematode damage at several and pointed up the need for more research in this field. A parallel survey for nursery fungi indicated that a *Fusarium* may be implicated in black root rot. These surveys showed most nurseries to be fairly free of important disease damage or to have diseases under control, but in some nurseries diseases were causing major losses in 1956.

Phomopsis blight of Arizona cypress was controlled with Special Semesan spray at 1 pound per 100 gallons of water, applied weekly during active growth. A new tip blight of this species has appeared, with which *Sclerotium bataticola* and *Alternaria tenuis* are commonly associated.

White Pine Blister Rust

Over 99 percent of the rust control acreage in North Carolina and Tennessee is on maintenance, with the rust being held in check. Primary attention has been given to the search for ribes around white pine plantations established and proposed, rechecking of areas eradicated in the past, technical supervision and assistance to eradication crews, and the keeping up to date of ribes ecology maps. State funds of North Carolina and Tennessee support much of this technical assistance program.

A rust damage study initiated in an unprotected area (ribes not removed) in Ashe County, North Carolina, in 1946, shows mounting losses from white pine blister rust (table 4).

Table 4.--Losses of white pine from blister rust in an unprotected area in North Carolina

Tree size class in 1946	Trees observed	White pine mortality					
		1946	1948	1950	1952	1954	1956
	Number	Percent					
Trees over 10 feet high	117	1	2	4	8	8	10
Trees 1 to 10 feet high	34	0	6	15	32	38	38
Seedlings 0 to 1 foot high	100	0	1	2	8	12	18

Defects in Hardwoods

An intensive study of hardwood defects in Georgia, North Carolina, and South Carolina has provided data on 596 trees of 34 species. While the study is not completed, a preliminary analysis showed 15 percent of the trees to have major disease defects. The commonest were *Endothia parasitica* cankers on 16 percent of the post oaks, *Poria spiculosa* cankers and rot in 7 percent of the hickories and 3 percent of the red oaks, *Polyporus hispidus* cankers and rot in 3 percent of the red oaks, heart rot from fire scars in 4 percent of the hardwoods, and unidentified rots and cankers in 6 percent of the trees.

Twenty examples of the more important defects have been prepared by sectioning billets on a bolter saw, and sectioning has also been done in the field to provide data on internal defect associated with external signs.

Pitch Streak of Slash Pine

This disease, confined to turpentined or otherwise wounded trees, is associated with dry-face and results in greatly elongated, dead, bleeding streaks above dry-face, and often in ultimate death. It appears to be one of the results of dry weather conditions over a period of years in south Georgia and north Florida. It is much more common on suppressed and intermediate than on dominant trees, and on wood-chipped than bark-chipped trees, and on trees of low crown ratio (fig. 26). It has been particularly severe on pond-margin and old-field sites, where the trees react more severely to acute moisture deficiency.

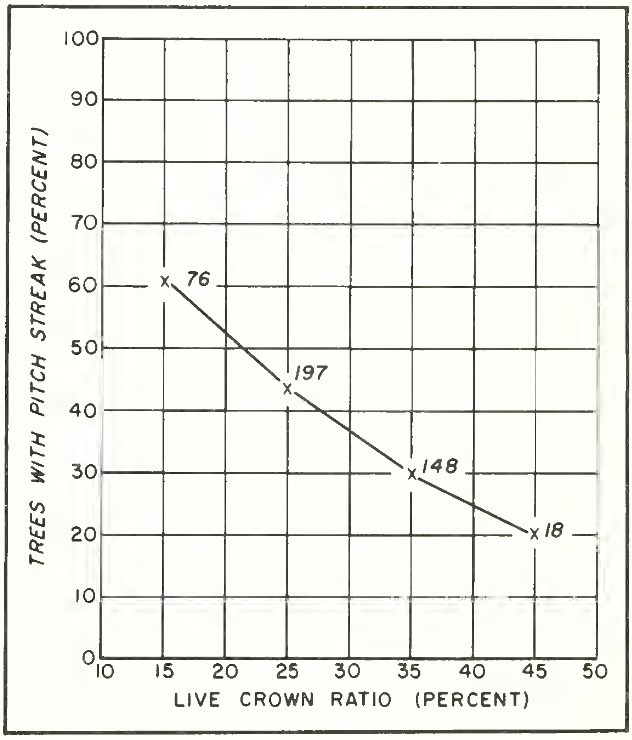


Figure 26.--Pitch streak occurrence in relation to live crown ratio. Numbers beside the plotted points indicate the number of trees upon which each point is based.

Miscellaneous

Sapstreak disease.--There has been no increase in sapstreak cases since 1953 on a 13-acre study plot of 78 sugar maples near Asheville, North Carolina. A few cases of the disease appeared earlier. Inoculation of 156 sugar maples and 120 yellow-poplars from 1949 to 1951 with the sapstreak fungus, Endoconidiophora virescens, has resulted in 20 sugar maples and 5 yellow-poplars becoming diseased.

Virginia pine rust.--Further inoculations with aeciospores of Peridermium appalachianum applied to Buckleya distichophylla resulted in uredial and telial production, providing confirmation of this Station's earlier work indicating that Buckleya is the alternate host of this Virginia pine rust.

Hot water treatment of pine seedling roots.--At Lake City, a study to determine the ability of 1-0 slash and sand pine seedlings to withstand hot water treatment for nematode control has been completed. The results indicate that both species can tolerate immersion of their roots in hot water at temperatures and time intervals (116° F. for 25 minutes) which are known to destroy cyst-type nematodes.

Chestnut blight.--Scions from some possibly blight-resistant American chestnuts have been successfully bridge-grafted into Asiatic chestnut stocks (fig. 27).

Figure 27.--Shoots from American chestnut bridge-grafted into stem of Asiatic chestnut to test former for resistance to chestnut blight. Stock stem will be gradually removed to force buds on the scion.

Measurements of a plantation near Asheville, North Carolina, of 5 of the best strains of Chinese chestnuts 3 years after establishment show the trees on the plots located on a cove site average 4.4 feet in height and those on an adjacent oak plot 2.3 feet.

Pitch canker.--Virginia pines have been successfully inoculated with spores of *Fusarium lateritium pini* applied to injured and uninjured needles, indicating that needle infection may take place in nature, although intensive search for a fruiting stage of the fungus in nature has been unsuccessful thus far.

FOREST INSECTS

The insect research program began on a small scale late in 1954 with analyses of the problems in the area. Since then, it has included short term studies of emergency problems, and important basic research has been started. A considerable part of the Division's effort goes into survey and control of forest insect outbreaks. This load increased in 1956 because of increased insect activity and greater desire on the part of land owners for protection.

Southern Pine Beetle

The continuation of the southern pine beetle epidemic in the Southern Appalachians required frequent aerial surveys and ground checking to maintain current data on the status of the infestation. Seventy-eight hours of flying time were needed. During the first half of 1956, the outbreak appeared to be waning. In late July, however, beetle attacks increased sharply (fig. 28) and continued high for the remainder of the year. It is estimated that a total of about 6 million board-feet of Virginia, shortleaf, and pitch pine were killed this year in the Southern Appalachians. Approximately 40 percent of this volume was salvaged.

Chemical control operations continued during the year. A total of 63,368 trees were cut and sprayed with a $\frac{1}{4}$-percent fuel oil solution of gamma benzene hexachloride; 42,768 trees were treated on National Forest lands; 10,000 on Park Service lands including several hundred on lands of the Cherokee Indian Reservation; and 10,600 on private lands by the State of North Carolina. Due to a long, warm autumn that kept beetle activity high, an estimated 29,000 infested trees remained in epidemic areas at the end of the year.

A study to determine the accuracy with which southern pine beetle infestations could be visually mapped from the air was started during the year in the Asheville Basin and Tellico Plains areas in cooperation with the Forest Insect Laboratory at Beltsville, Maryland, which furnished the plane, pilot, and two experienced observers. Three experienced observers each mapped independently of the others the infestations on two large areas. Infested trees were plotted on county road maps with a scale of $\frac{1}{2}$ inch equals 1 mile. All trees within each of three strip widths were plotted. Strip widths were $\frac{1}{2}$, 1, and 2 miles. In addition, altitudes of 1,000 and 2,000 feet were tested. Infested trees were classified into groups of 1, 2 to 5, 6 to 20, 21 to 50, and more than 50. Results of this study showed that all observers could plot large spots more accurately than small spots, that accuracy increased with decreasing width of the strip, and that there was no significant difference among experienced observers.

A study was started to determine the silvicultural and ecological relationships which predispose a stand to southern pine beetle attack. It is hoped that the results of this study will lead to an understanding of the causes of beetle attack, and in turn silvical treatments which will modify stand conditions to prevent or minimize southern pine beetle outbreaks.

Ips Engraver Beetles

No major Ips beetle outbreaks occurred in the Southeast during 1956. Nevertheless, pine mortality in single trees or small groups accounted for a volume loss of millions of board-feet of all species of pines. The most concentrated beetle attacks were in central South Carolina and extended into Georgia, with heavy attacks also along the coast of South Carolina.

Rapid salvage operations by pulp companies, private owners, and the U. S. Forest Service did much to prevent losses in large areas devastated by late spring fires in north Florida and south Georgia.

A study at Lake City, Florida, was started in cooperation with the Divisions of Fire and Management Research to determine whether mortality of slash and longleaf pine trees could be determined by external manifestations of fire. In order to determine the mortality due to fire alone, an attempt was made to prevent Ips attack on half the study trees by spraying them with $\frac{1}{2}$ percent gamma benzene hexachloride emulsion. Though the study is still in progress, preliminary observations indicate that the beetles were prevented from attacking trees adequately sprayed prior to attack.

Black Turpentine Beetle

The turpentine beetle continued to cause timber losses, and control was frequently necessary in the turpentine belt of Florida and Georgia.

Control on the Osceola National Forest in northern Florida and on adjacent private lands was intensified as a result of the 130,000-acre fire in March. Fire-weakened trees, as well as stumps resulting from salvage logging, created ideal material for beetle development. On National Forest Land 24,000 trees and stumps were sprayed to reduce beetle losses.

Figure 28.--Aerial view of southern pine beetle kill in western North Carolina.

Heavy beetle populations were detected in the mountains of north Georgia, where some logging areas have beetles in 75 to 92 percent of the stumps. Beetle populations are being chemically controlled in areas of heaviest infestation.

In the vicinity of New Bern, North Carolina, an epidemic has developed in the pocosin type following logging. Because of extremely dense underbrush, it was necessary to run a bulldozer around

each tree to break down the brush. Even with such treatment, fellers had difficulty in cutting trees close to the ground, and 3-foot stumps were commonly left. Beetle populations which built up in these stumps have since attacked and are killing residual trees. Very heavy larval populations were found as high as 7 feet in many of these standing pond pines. Continued pine losses can be expected unless control is carried out.

Most of the major objectives of the study of the biology, ecology, and control of the black turpentine beetle at Lake City, Florida, have been achieved, but work is continuing to determine the length of the residual effectiveness of benzene hexachloride, effect of the insecticide on gum flow, and effectiveness of control in preventing tree mortality in naval stores areas. Major efforts during the year were made to summarize the data for publication.

Pales Weevil

The study to determine a control for pales weevil on cutover pine lands was repeated in ten areas throughout the Southeast. Second year results verified last year's tests and again showed that spraying the seedlings and soil surrounding them following planting provided more protection than simply dipping the tops of the trees in insecticide prior to planting. However, the spray protection may cost several dollars per acre, whereas the dip treatment costs only 10 to 15 cents per acre. When weevils appear unexpectedly on untreated planting stock, or when valuable, special, or wildling seedlings need protection, the spray treatment may be justified. Results of the second year's study show that, of the more promising materials tested, 2 percent aldrin emulsion used as a dip provided 94 to 100 percent protection, whereas spraying with this material provided 100 percent protection in areas where 1 to 30 percent of the untreated check trees were killed by pales weevil attack. Various types of weevil damage are shown in figure 29.

A $\frac{1}{2}$-acre pine stand at Bent Creek, North Carolina, was clear cut in December 1955. High-value grafted Virginia pine seedlings were planted in the area the following May. These seedlings were sprayed with a 2 percent heptachlor emulsion to prevent serious injury by reproduction weevils. As an additional precaution, several traps were constructed. These were simply shallow trenches containing several 18-inch-long pine bolts 2 to 3 inches in diameter and covered with fresh pine boughs (fig. 30). The material in the traps was also sprayed with 2 percent heptachlor to kill beetles coming to the traps. Nearly 4,000 weevils were collected in the traps from May through November. Figure 31 shows the trend of the trap collection during the summer. Weevil populations were very high during May and June but declined gradually during the summer and fall. Nearly 90 percent of the weevils collected were pales, 9 percent Pachylobius picivorus, and the remainder Pissodes spp. plus a few miscellaneous species (fig. 32). Although some pales feeding occurred on 17 of the 25 high-value seedlings during May and June, no seedlings were killed.

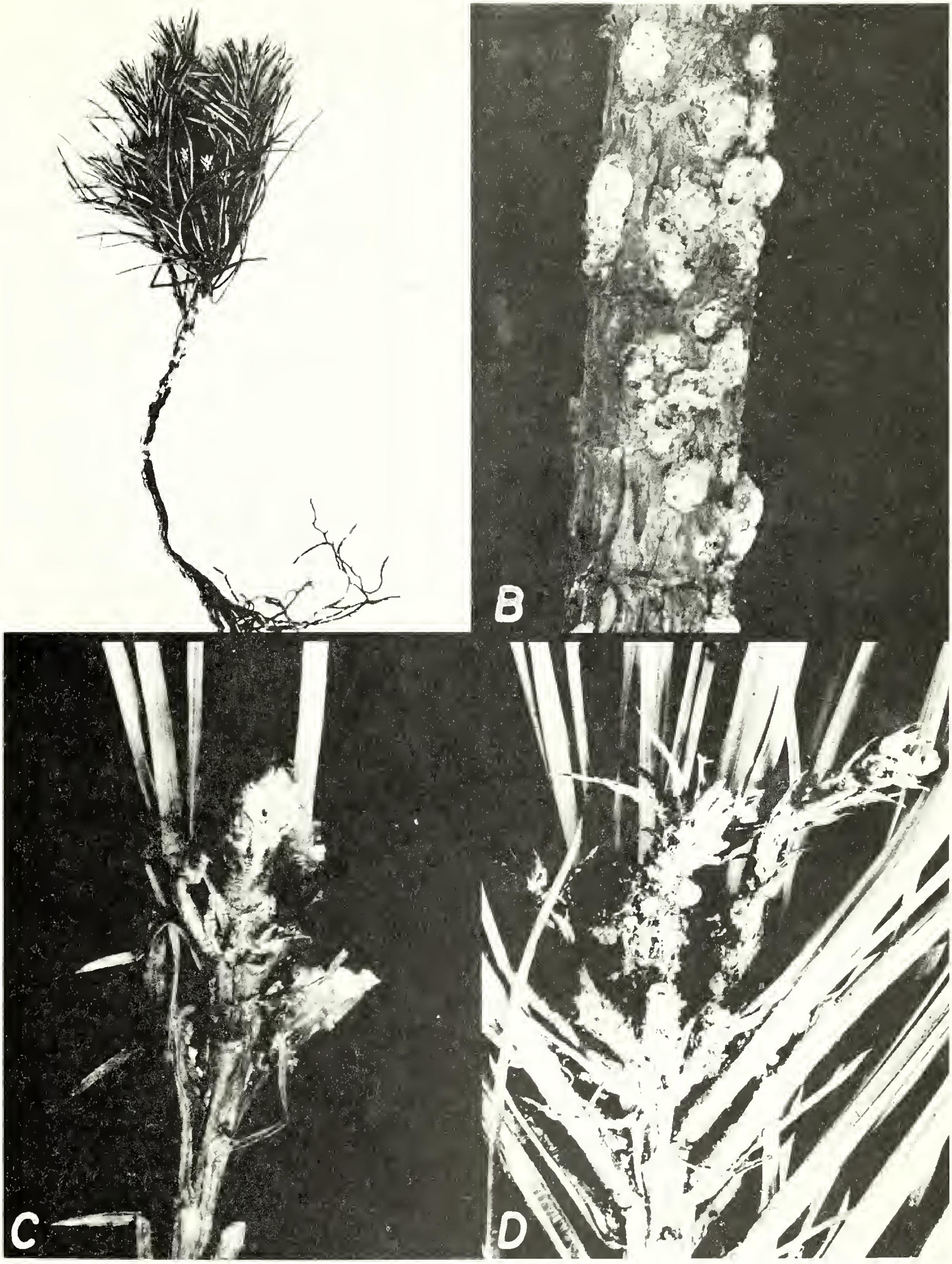


Figure 29.--Types of damage caused by pales weevil feeding on pine seedlings. A, Girdling and killing of entire tree. B, Scattered feeding which generally heals over. C, Feeding on the new bud. D, New growth intensively fed upon and killed, which results in a bushy seedling.

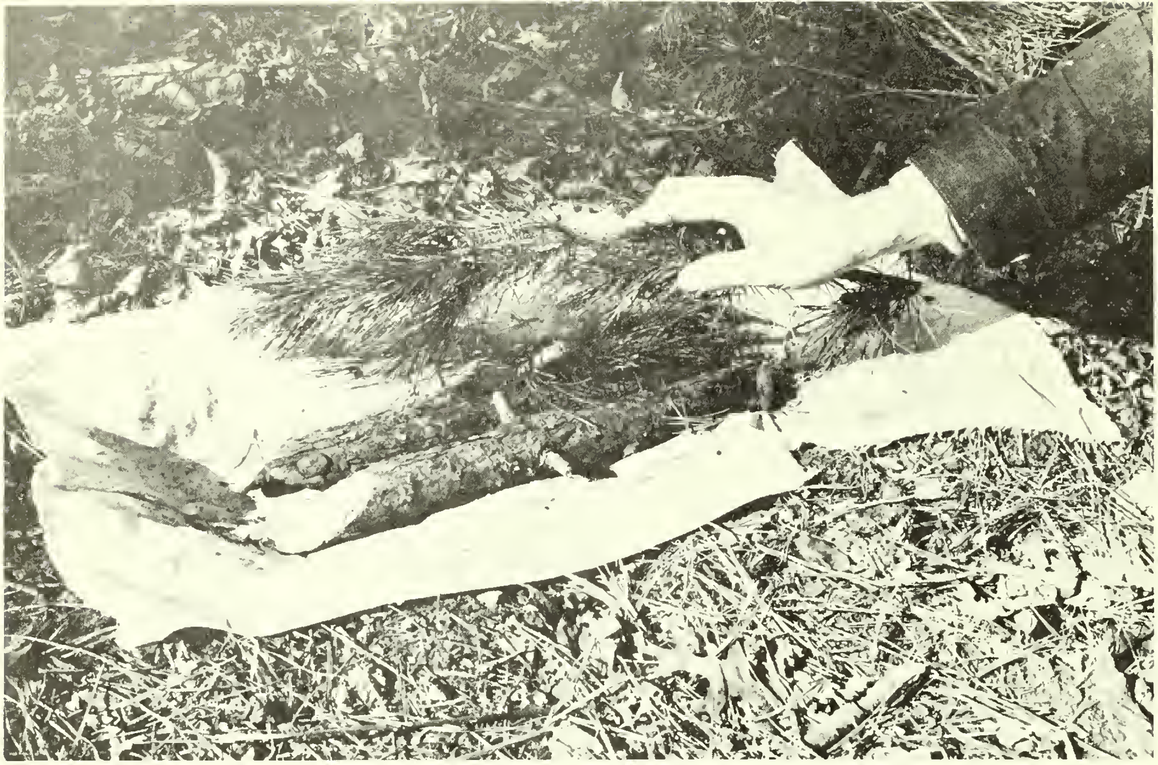


Figure 30.--Preparation of trap for collecting reproduction weevils. Cloth lining in trench is not necessary unless weevil counts are desired.

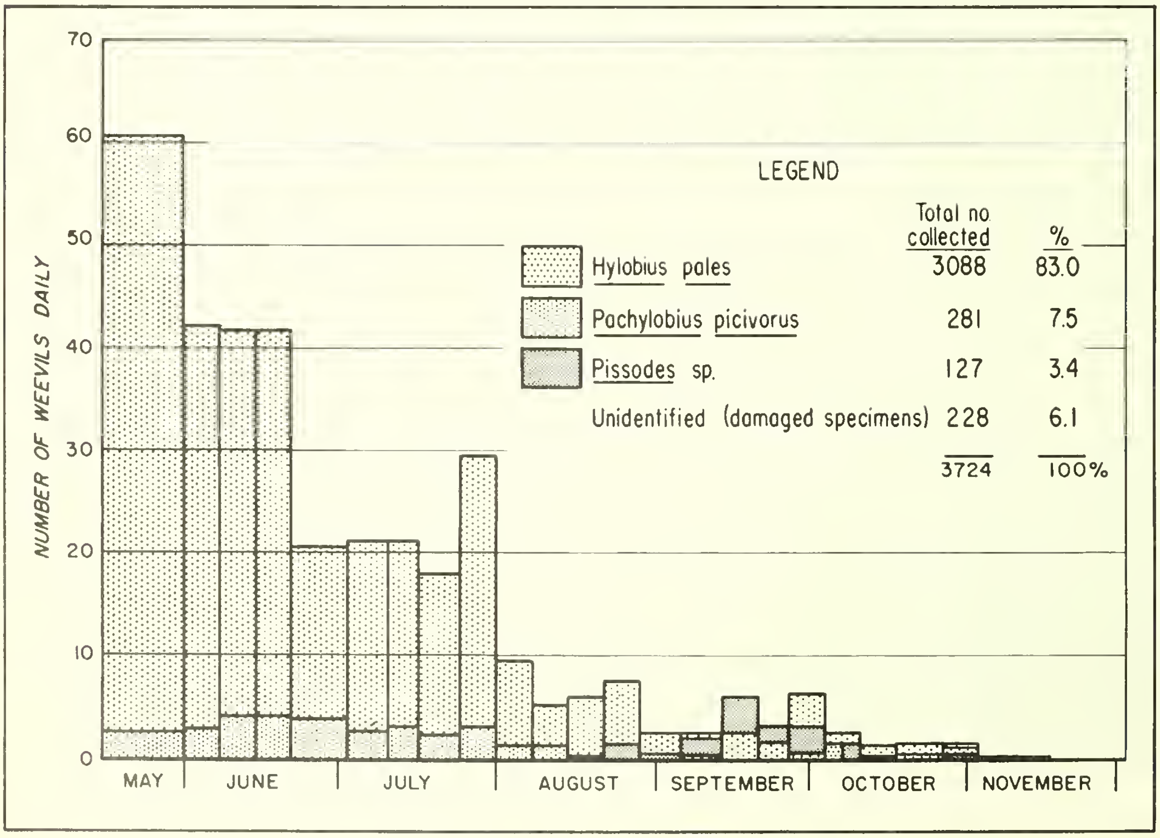


Figure 31.--Trap collections of weevils during 1956 at Bent Creek, N. C.

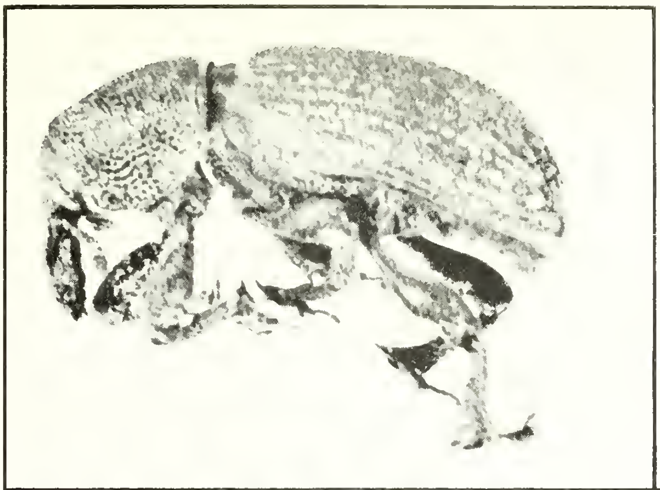
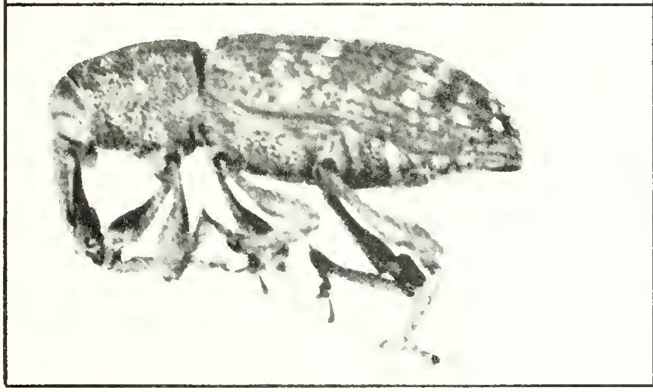


Figure 32.--Common reproduction weevils. Upper left, pitch-eating weevil, *Pachylobius picivorus*. Lower left, pales weevil, *Hylobius pales*. Below, deodar weevil, *Pissodes nemorensis*. Beetles are actually from about 3/8 inch to 1/4 inch long, respectively.



White Grubs

The study commenced in August 1955 to determine the rate of movement of white grubs through the soil and whether grub feeding was concentrated on the roots of grasses or on pine trees in plantations at the Savannah River Project was completed in June 1956. Minute pieces of radioactive tantalum wire were injected into the body cavity of grubs. The grubs were then replaced in the soil under five different conditions of ground cover to determine whether type of ground cover affected larval movement. Weekly checks of direction and distance of movement were determined for each grub. Results of these examinations are shown in the tabulation.

Grub movement	Grubs (Number)
Lateral movement of grub from 5 to 36 inches	8
No lateral movement of grub following treatment	43
Rapid or abnormal movement of source of radioactivity (Generally believed to be caused by ants)	29
Search did not relocate radioactivity within 40 inches of release point	20
Total grubs treated	100

Ants feeding on the grubs caused the loss of over half the grub population. One day following treatment, some of the treated wire was found more than 20 feet from the release point on or in ant hills. Improvement in techniques of handling and treating the grubs are required before the study is repeated. Cooperating in this study were the Savannah River Project of the AEC and the Beltsville Forest Insect Laboratory.

Insects Destructive to Flowers, Cones, and Seeds of Pine

A project analysis was completed for research at Lake City, Florida, on insects destructive to flowers, cones, and seeds of southern pine trees. This study was begun in response to the need for finding a means of protecting seeds and cones from insects which in some years may destroy 75 percent or more of the crop. Without protection, the anticipated future supplies of seed from seed orchards, selected, and superior trees in the expanding tree planting program may never been realized.

Variable Oak Leaf Caterpillar

The variable oak leaf caterpillar became epidemic throughout millions of acres in an area extending from Delaware to northeastern North Carolina. White oak was completely defoliated in many timber stands where that species comprised a high proportion of the stems. No tree mortality has been known to occur and if the present epidemic runs in its usual manner, defoliation will be much less severe in 1957.

Snow-White Linden Moth

For the second successive year the snow-white linden moth has caused heavy defoliation of hardwoods in northern Georgia. This epidemic, detected in 1955, caused light to heavy defoliation of 50,000 acres in 1956. While defoliation of hickories, oaks, and walnut was complete in limited areas, no tree mortality has been observed.

Pupal parasitism was found to be 36 percent. Dead larvae were found by the thousands in silken webs which they had spun down from the trees (fig. 33). It is hoped that the factors causing the death of these larvae, plus other biological agents, will bring the outbreak to a close.

Figure 33.--Dead larvae of the snow-white linden moth attached to silken webs they had spun down from defoliated hardwood trees.

Service

Requests by the general public increase every year and continued to mount in 1956. In addition to furnishing such information, members of the Division participated in 39 meetings at which discussions and 18 papers were presented to over 2,000 persons.

RANGE MANAGEMENT

Browse Plants of Georgia Coastal Plain Contribute to Cattle Diet

During 1956, useful information about the dietary contributions of browse plants was reported in a cooperative study with the Georgia Coastal Plain Experiment Station, the Animal and Poultry Husbandry Research Branch; and Plant, Soil, and Nutrition Laboratory of the Agricultural Research Service. Browse includes twigs, shoots, and leaves or woody vines available for grazing by livestock and game. These plants can contribute substantially to animal feed supply and nutritional intake; and certain species may be high in a specific nutrient or mineral that is deficient or marginal in other kinds of forage. Too, the browse generally shows less seasonal fluctuation in chemical content than do the grasses, and retains its crude protein and mineral better during the winter. This is of considerable significance for deer and other game because of year-round dependence on native forage.

In south Georgia, browse plants as a group contributed about 16 percent of total cattle feed during winter and spring on the Alapaha Experimental Range. Lowest consumption (4 percent) was in early fall. Young shoots, buds, and leaves of nearly all browse were consumed to some degree during the spring (fig. 34) with summersweet clethra, bedstraw St. Johnswort, blackgum, and sawpalmetto the most important species. When herbaceous feed became dry, unpalatable, and of low quality in late fall, browse again supplied a larger portion (16 percent) of the cattle diet; and grazing was confined primarily to such evergreen plants as American cyrilla, myrtle dahoon, sweetbay magnolia, sawpalmetto and laurel greenbrier. Deer, being browse eaters, doubtless would consume more of these plants than was observed for cattle.

Chemical analysis of individual browse plants (table 1) shows a fairly high crude protein level of 8 percent--sufficient for livestock maintenance--during the winter, when protein of average cattle diet dropped to a low of 5 percent. Most browse contained more calcium than other forage and a greater amount than is ordinarily required for animal maintenance. This mineral was highest in browse consumed during the winter and thus greatly lessened the need for mineral supplements.

Figure 34.--Cattle seek young shoot and bud growth of many browse plants in the early spring.

Table 1.--Crude protein and mineral content of coastal plain browse plants

Browse species and season of collection 1/	Crude protein	Calcium	Phos-phorus	Copper	Cobalt
	- - - - - -	Percent	- - - - -	Parts per million	
Spring					
Summersweet clethra	13	0.93	0.12	10.6	9.30
American cyrilla	13	.30	.17	8.1	.09
Bedstraw St. Johnswort	10	.34	.10	--	--
Blackgum	13	.65	.12	7.8	6.90
Sawpalmetto	7	.09	.13	17.0	.06
Winter					
Myrtle dahoon	8	.62	.06	6.3	.12
Sweetbay magnolia	10	.55	.10	5.0	.06
Laurel greenbrier	9	.44	.07	4.7	.05

1/ Other browse plants of lesser importance were red maple, red chokeberry, buckwheattree, gallberry, running oak, and staggerbush.

In general, browse plants were low in phosphorus and, in this respect, not greatly different from other kinds of forage. The phosphorus level of several plants, however, approached that required by cattle.

Certain minor element deficiencies, often reported in areas of the Southeast, may be overcome where certain browse plants are available. Blackgum and summersweet clethra contain relatively large amounts of cobalt; and ample amounts of copper are present in most browse plants. Sawpalmetto, running oak, and summersweet clethra are particularly high in the latter element. Enough iron, manganese, and zinc are contained in both herbaceous vegetation and browse to fulfill animal needs.

Some evidence suggests that minor elements may influence cattle grazing habits. For example, sawpalmetto may be eaten for its copper and summersweet clethra and blackgum for their cobalt.

Cattle Production on Burned Wiregrass-Pine Ranges

Cooperative range studies at Alapaha continue to demonstrate the benefits of a good fall-winter maintenance ration and use of crossbred cattle that include some Brahman blood (fig. 35).

Figure 35.--Calf production has been good from crossbred Brahman-Hereford cows grazing burned wiregrass range.

The experimental herds include essentially two kinds of cattle: (1) crossbred Brahman-Herefords and (2) grade Hereford cows; and both kinds are bred to Shorthorn bulls. Approximately 15 acres of open cutover land or 20 acres of burned timbered range are available for each cow from March 15 to October 15. Cows are maintained at a relatively high level during the rest of the year on coastal Bermuda grass and small grain pastures or dry-lot hay.

Calving percentage for crossbred cows during the 4-year period 1953-1956 has been 86 as compared to 69 for the grade Hereford cows. In addition, the former have consistently produced heavier calves at weaning time in October. Comparative weaned weights in pounds per calf (adjusted to age of 224 days) are indicated below:

	Calves from crossbred Brahman-Hereford cows (Pounds)	Calves from grade Hereford cows (Pounds)
1953	406	360
1954	391	--
1955	469	383
1956	495	423

Except for the drought year 1954, weaned calf weights have steadily increased. Since the same cows have been used through the entire study, this reflects, among other things, the ability of the older cows (up to 9 years of age) to respond to better management and more efficient use of the native range.

Native Cane Response to Burning in the North Carolina Coastal Plain

In the past, periodic wildfires have had much to do with development of the cane forage type in coastal North Carolina; but now that improved protection has reduced the number and frequency of fires, the cane stands tend to thin out and decline in productivity.

Cooperative studies at the Tidewater Research Station, North Carolina, from 1948 to 1955 show that cane unburned for 14 years declined in stem numbers some 65 percent during the final 7 years. The reduction was similar under trees and in the open; and natural thinning apparently exerted a stronger effect than grazing upon stem population. Moreover, relief from grazing did not bring the unburned range back to high productivity.

In an attempt to renovate decadent cane stands, several small ranges which had been protected from fire for 12 years were winter-burned in 1953. Vigorous sprouts replaced the old cane. Foliage production beneath trees and in the open was greater the second and third year after burning than before the fire. These and other observations suggest that cane range should be burned at intervals of about 10 years. Complete renovation of the stands can be expected within 2 to 4 years after burning, and reasonably good production can be maintained an additional 6 to 8 years. However, grazing should be carefully regulated during the summer months, particularly during the period of renovation.

Mineral Consumption by Cattle on Low-Quality Forest Range in South Florida

During the year, grazing trials to determine proper stocking rates on cutover pine lands were started on the Caloosa Experimental Range in south Florida with cattle furnished by the cooperating Babcock-Florida Company (fig. 36). Sampling studies to observe range condition and trend and herbage production were begun, and periodic weights and other data obtained from the experimental herds in preliminary investigations scheduled over a 2-year calibration period. Among the first of the observations were those of mineral consumption during the initial period, March to December.

Figure 36.--Group of Caloosa Experimental Range cows and calves used in the grazing trials in southern Florida.

The mineral supplement selected for use on the Caloosa was developed by the Florida Agricultural Experiment Stations through extensive research, and its formulation is presented in Bulletin 513 (1953). It was available at all times in each range unit and actual consumption was measured for each approximate 2-week period (fig. 37).

It might appear that increasing needs for minerals during lactation would account for the general rise in consumption to the peak for the July 20 to August 2 period, since the experimental herds had only 7 calves at side on March 1 compared to 51 on August 2. However, after weaning 43 calves on September 1, consumption rose to amounts even higher than when

calves were at side and the majority of the cows were lactating following a marked reduction in consumption the first 2 weeks after weaning. Factors other than lactation evidently account for these fluctuations, but requirements due to pregnancy apparently were not controlling, since only a few of the lactating cows bred back during the spring breeding season. Declining quality of the vegetation apparently accounted for the fluctuations.

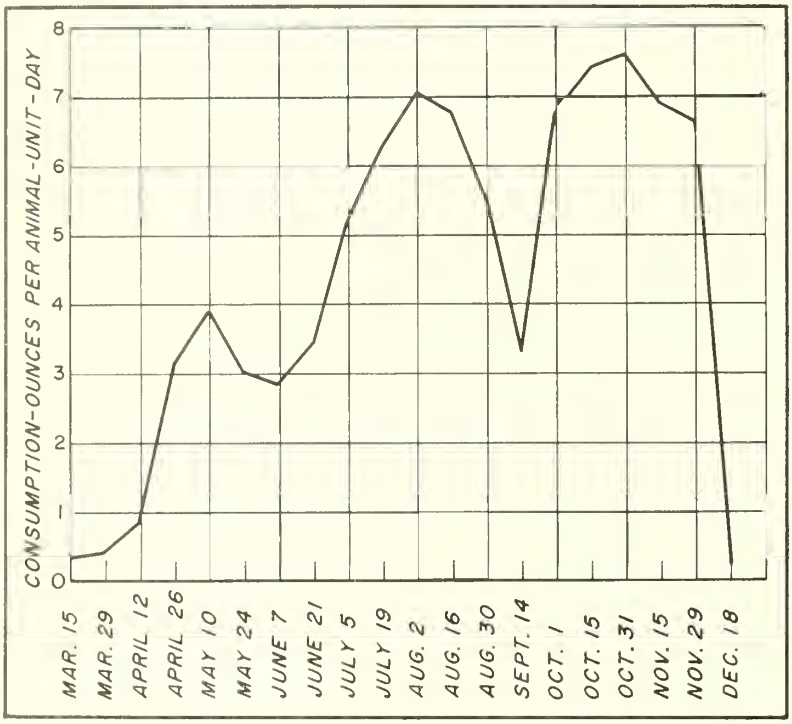


Figure 37.--Consumption of minerals in ounces per animal-unit-day by 2-week periods, March 1 through December 18, Caloosa Experimental Range.

The spring and summer of 1956 were abnormally dry, with precipitation only about two-thirds of normal for the period January through August. The deficiency was particularly severe on the Caloosa during the spring growing season, March through June. During this dry spell, plant growth on the unburned experimental ranges was poor, and cattle had to depend largely on residual feed from the previous year. It was quite evident that herbage was of low nutritive value, and as a consequence, the animals increased their consumption of minerals to meet body needs.

With a change to fresh unburned pasture on September 1, there was a significant drop in mineral consumption during the first 2 weeks the cattle were in those ranges. Part of this drop was due to change in habitat, and part of it was the availability of some good quality herbage in pond forage types. Once the animals became accustomed to the new range and had eaten off the available good forage, mineral consumption returned to high levels until the animals were moved onto freshly-burned range on December 1. The lush wiregrass forage of the freshly-burned range apparently met animal requirements, for mineral consumption then dropped to a low of $\frac{1}{4}$-ounce per animal-unit-day.

Substantiating the apparent ability of freshly-burned range to meet animal mineral requirements are data obtained in 1956 for the Caloosa replacement herd. This herd was turned onto the replacement range on March 1--one-fourth of which had been burned in February--and grazed continuously there until October 1. The herd grazed separate unburned range during October and was then turned back onto the replacement range, part of which had been burned meanwhile.

For six of the eight 2-week periods between March 1 and June 21, no mineral was consumed by the replacement herd and only a trace in the two other 2-week periods. However, mineral consumption ranging from 1.33 to 2.87 ounces per animal-unit-day was observed as forage matured and the animals began to graze more on the unburned portions of their range. In October, when this herd was moved to a separate range with no 1956 burn available, their mineral consumption rose to 5 ounces per animal-unit-day. Upon return to the replacement pasture, with freshly-burned forage available, consumption dropped to less than 2 ounces per animal-unit-day.

FOREST MANAGEMENT

Two important summaries of forest management research and experience were issued during the year. U. S. Department of Agriculture Farmers' Bulletin 2097, "Growing Loblolly Pine in the South Atlantic States," by Thomas Lotti, gives directions for handling loblolly pine as a paying crop from seed to final harvest in Virginia, North Carolina, South Carolina, and Georgia. And USDA Farmers' Bulletin 2103, "Growing Slash Pine," by Kenneth B. Pomeroy and Robert M. Cooper, covers management, protection, and harvesting of slash pine throughout its range.

The Station's program of research in forest management is going through a constant readjustment to meet changing conditions. For instance, more effort in the last 2 years has gone into hardwood management to parallel the Station's new research in hardwood utilization. We are also speeding up research on seed, nursery, and planting problems, site preparation, plantation care, and the production of superior strains of trees for the tremendous southern planting program.

Artificial Regeneration

Of the commercial forest land needing planting in the United States, one out of every 5 acres is in the five Southeastern states. To this idle land must be added a large area of southern pine forest that is being clear cut and planted, and an unknown quantity of agricultural land that will be converted to trees under the Soil Bank Program. Modern techniques need to be developed for this huge job of growing and planting tree seedlings.

Preharvest Loss of Cones and Seed in Slash Pine

Southern pine seed has suddenly become a precious resource. The Soil Bank Program coinciding with a seed crop failure in 1956 has dramatized the importance of seed in a coming era of man-made forests. Studies at the Lake City Research Center indicate that a high loss in potential seed occurs in slash pine between the time of flowering and cone harvest. Such losses can be extremely expensive in large-scale regeneration and genetics programs.

One set of data shows that 755 flowers produced only 240 mature cones, indicating that 68.2 percent, or more than two-thirds of the potential cones, failed to reach maturity. Another set deals with 440 pollinations on 51 trees of various ages over a 3-year period, in which a low of 30.5 percent and a high of only 45.1 percent in mature cones were realized.

Furthermore, cones in themselves do not assure seed, for insects, squirrels, adverse weather, and disease all take their toll of the crop. In a seed production area in north Florida, all cones, totaling 280, were harvested from 13 selected cone-producing trees. Of this number, 21.9 percent were worthless, 22.7 percent were partially damaged by insects, and only 55.4 percent were sound. These percentages are indicative of the losses that occur. Another set of data shows 83.7 percent sound, 13.8 percent partially damaged, and only 2.5 percent worthless.

Nursery Techniques for Sand Pine Seedlings

In a study of nursery techniques for growing sand pine seedlings, the Lake City Research Center has shown that seedbed shading significantly increased outplanting survival of 1-year seedlings (1-0 stock). Fertilization was also helpful. Seedlings kept in the nursery bed for $1\frac{1}{2}$ or 2 years ($1\frac{1}{2}$-0 and 2-0 stock) survived very poorly in the deep sands of the Ocala National Forest because they developed excessive top growth in the nursery (fig. 38). Seedlings of the west Florida (Choctawhatchee) race of sand pine survived twice as well as those of the central Florida (Ocala) race, even though they were grown in the same nursery and planted at Ocala. The west Florida race has the further advantage of producing cones that open at maturity. These findings all favor the use of the west Florida race in reforestation programs.

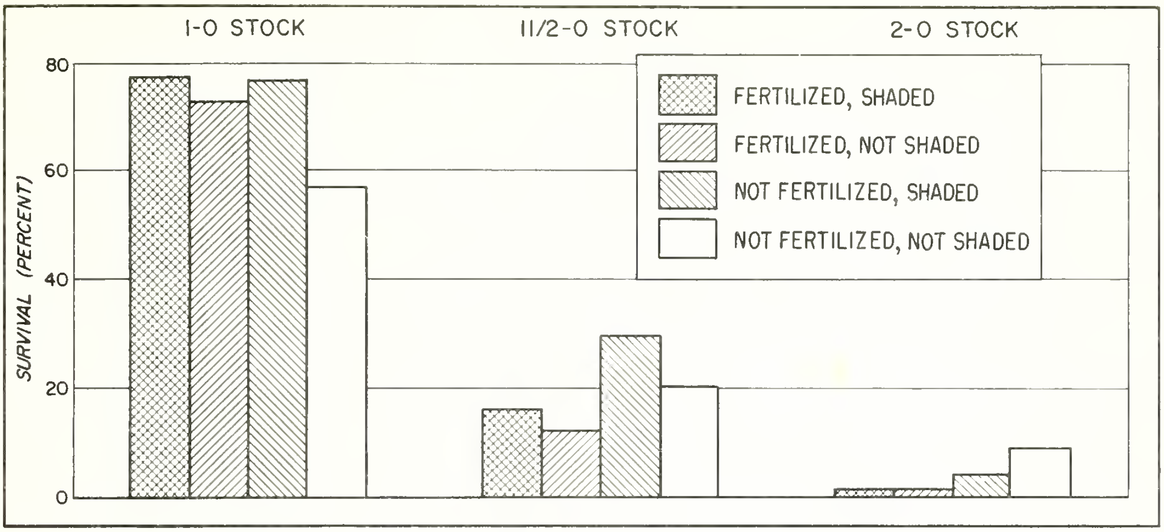


Figure 38.--Survival of sand pine planting stock 22 months after outplanting, in relation to nursery treatments.

Early Growth of Planted Slash Pine

Slash pine, the most planted tree in the United States, gains a good measure of its fame from its rapid growth compared with other conifers. Slash pine seedlings do not, of course, make rapid growth immediately. Annual height measurements for 3 years following planting show that field-planted slash pine in the middle Coastal Plain of Georgia averaged about 0.5 foot the first year, 1.9 feet the second, and 2.9 the third (fig. 39). The third year's growth is close to the average that all old-field plantings on the George Walton Experimental Forest have made throughout their life.

Seasonally, the greatest height growth in these stands occurred in April. In 1954, approximately 60 percent of the growth was completed by April 30, and 77 percent by May 31 (fig. 40). On similar dates in 1953 percentages were 55 and 68, respectively. In 1953 about 20 percent of the growth occurred after June 30 but in 1954 only about 10 percent was added after this date.

Spacing Affects Diameter Growth as Early as Fifth Year

Number of trees planted per acre affects the diameter of slash pines as early as the fifth year, according to the results of a spacing study at the George Walton Experimental Forest, Dooly County, Georgia. The results shown in figure 41 indicate that even 15x15-foot spacing is limiting diameter growth at this early age. The study shows no additional effect of square versus rectangular spacing for comparable numbers of trees per acre. Height growth, although rapid, has not been affected by spacing. A basic study of the soil-moisture relationship in the various spacings will be made in 1957.

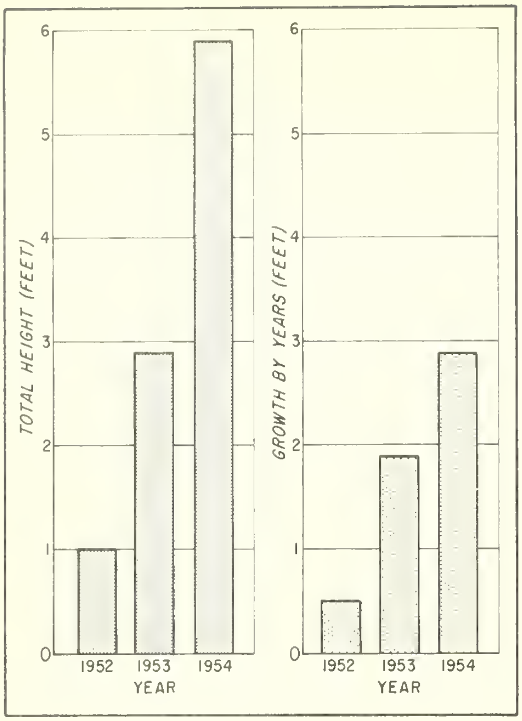


Figure 39.--Height growth of field-planted slash pine during the first 3 years after planting.

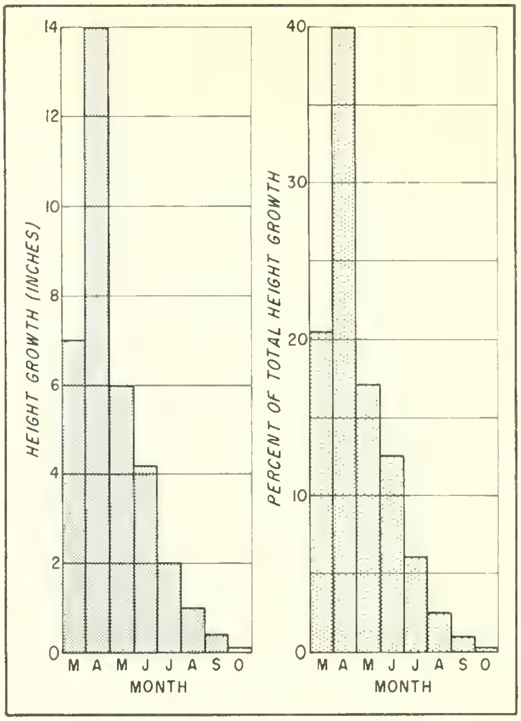


Figure 40.--Monthly height growth of field-planted slash pine during the third growing season.

Wide Spacing in Planted Slash Pine

A growing interest the past two decades in early returns from young pine stands has now intensified in the Southeast through the provisions of the Soil Bank Program. Attention is focusing on the possibility of growing the trees to pulpwood size for thinning as early as 10 to 15 years hence. Fortunately, there are available in the naval stores belt many slash pine plantations which were planted at wide spacings to favor rapid development of individual trees for gum production. These plantations are of special interest now in showing the possibilities of wider spacing in shortening the period required for the production of timber crops.

Preliminary information on growth of slash pine plantations covering a wide range of spacings is given in Station Paper 66, "Growth of Slash Pine Plantations on the George Walton Experimental Forest." Average annual diameter growth was greater in the more widely spaced plantations, ranging from 0.41 inch in the 8x8-foot spacing up to 0.56 inch in the 16x16-foot spacing (fig. 42). This substantiates the study described above, where diameter growth reduction began early, even in widely spaced plantations. The narrow spacing had an average of only 8 sawtimber-size trees per acre at 14 years, while a 17x17-foot spacing had 77 sawtimber-size trees at 15 years. Board-foot volumes varied correspondingly, 8x8-foot to 11x11-foot spacings having less than 1,000 board-feet per acre at 14 years, while 15x15-foot spacing had up to 2,808 board-feet per acre, and a 17x17-foot spacing had 2,767 board-feet per acre at 15 years. Thus, wide spacings result in faster diameter growth and early merchantability, though generally at some sacrifice of cubic-foot volume production (figures 43 and 44).

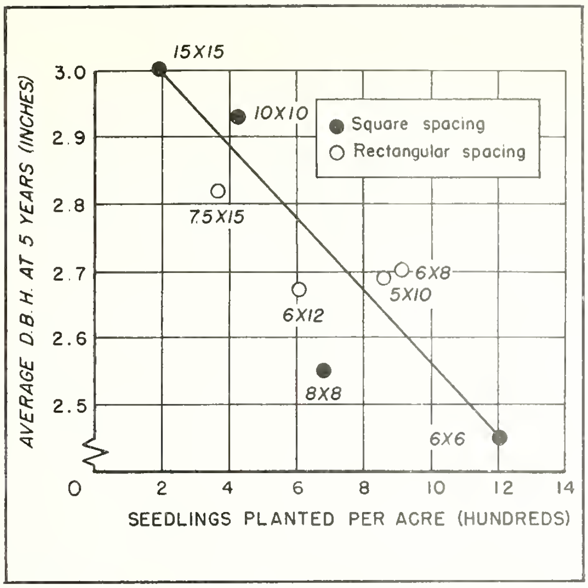


Figure 41.--Average d.b.h. of slash pine 5 years after planting, in relation to initial spacing.

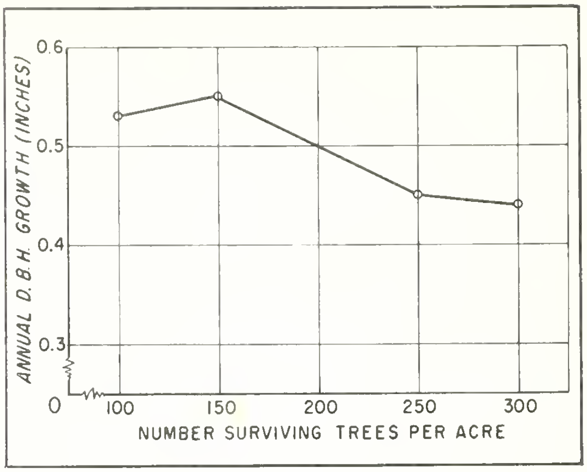


Figure 42.--Annual d.b.h. growth of planted slash pine in relation to number of surviving trees per acre at age 14 and over.

A more comprehensive and widespread study of the relationship of growth of slash pine plantations in Georgia to soil characteristics, stand density, and age was started in 1956 in cooperation with the School of Forestry of Duke University.

Growth of Slash Pine on Old Fields More Than Doubles That on Cutover Lands

Most of our information on the growth of southern pine plantations is based on old-field areas. However, a large share of the future planting by forest industries will have to be on wild land. Much more attention must be directed to the special problems that will be encountered on these sites.

Figure 43.--A 12-inch slash pine in a plantation 13 years old spaced 15x15 feet.

Figure 44. --A 19-year-old slash pine plantation spaced 15x15 feet. The average diameter was about 10 inches at this age, and there was a total of 7,500 board-feet of sawtimber per acre. Stumps in the foreground are from the initial thinning, which removed about 6 cords per acre.

Results of a study on the George Walton Experimental Forest in the middle Coastal Plain of Georgia highlight the need for site preparation on undisturbed soils. Figure 45 shows that early height growth of seedlings planted on old fields was more than double that on cutover lands. While soil types are generally comparable, the cutover areas are of slightly lower elevation than the old fields, thereby affording a special advantage from the standpoint of available moisture. Even so, survival on the fields averaged 75 percent as compared to 50 or 60 percent in cutover areas.

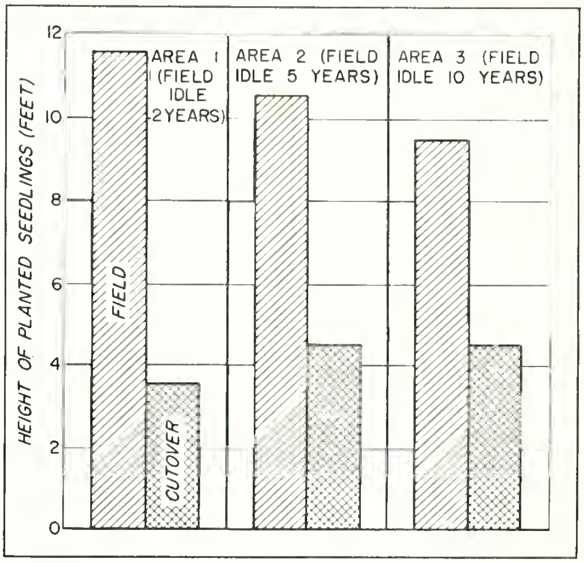


Figure 45.--The average height of slash pine seedlings 5 years after planting in old fields and in cutover tracts.

Furrow Old Fields to Plant Longleaf in the Sandhills

It has been general custom to plant old fields without thought of site preparation. However, a study in planting longleaf near Aiken, S. C., showed first-year survival of 92 percent for trees in furrows, compared with only 59 percent in the untreated area. Seedling vigor on furrowed areas was outstanding and pointed to early height growth.

The test was made where the "rough" was 7 to 8 years of age. Single furrows 8 inches deep and 24 inches wide were plowed to permit a spacing of 4x6 feet. Results suggest that in old fields the typical cover of grass and weeds may present serious competition for soil moisture and nutrients.

Furrowing resulted in an increase in soil moisture at depths of 3, 6, and 9 inches below the surface (fig. 46). As a result of this test and comparable investigations in the scrub oak type, approximately 8½ million seedlings were machine-planted in furrows on some 10,600 acres of old fields by the Atomic Energy Commission during 1955-56 as part of the large-scale planting program on the Savannah River Project.

Species Comparison on Sandhill Sites

Judging from an initial test involving survival of various species of conifers planted in the South Carolina Sandhills (table 5), a wider range of species may be adaptable there than was formerly thought possible.

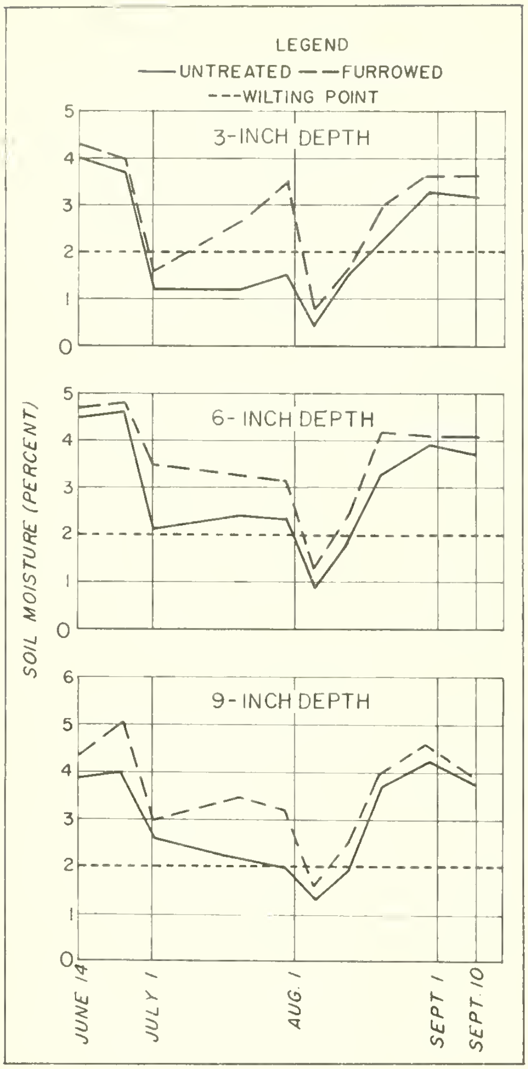


Figure 46.--Seasonal trend of soil moisture at three depths on furrowed and unfurrowed old fields.

Table 5.--Survival of coniferous species planted on Sandhill sites

Species	1st year planting (1955)	2nd year planting (1956)	Average 2 yrs.
	Survival percent		
Redcedar	99	87	93
Virginia pine	96	87	91
Loblolly pine	94	87	90
Shortleaf pine	89	87	88
Slash pine	95	77	86
Jack pine	--	80	--
Longleaf pine	81	65	73
Pond pine	77	68	72
Spruce pine	71	--	--
Lodgepole pine	--	47	--

Outstanding at this time is the good initial vigor exhibited by redcedar, slash, longleaf, Virginia, jack, and shortleaf pines.

Excessive crookedness and side branching are particularly marked among the pond pine, Virginia, shortleaf, spruce, and jack pines. The survival of jack pine in the second year replication is of special interest, since this species and lodgepole are far beyond their range.

A 6-Inch Difference in Elevation Markedly Affects Survival and Growth of South Florida Slash Pine

In south Florida an increasing area of land has been farmed a few years for truck crops, then abandoned, and now remains available for reforestation. Prior to cultivation, the low-lying sites were ordinarily too wet to grow pines. The ridges and furrows left by cultivation, however, change the picture. A preliminary test in cooperation with the Florida Board of Forestry, the Atlantic Land and Improvement Company, and the Collier Enterprise showed that after 3 years, survival of slash pine planted on the ridges was three times that of trees planted in furrows, even though the difference in elevation amounted to only 6 inches (fig. 47).

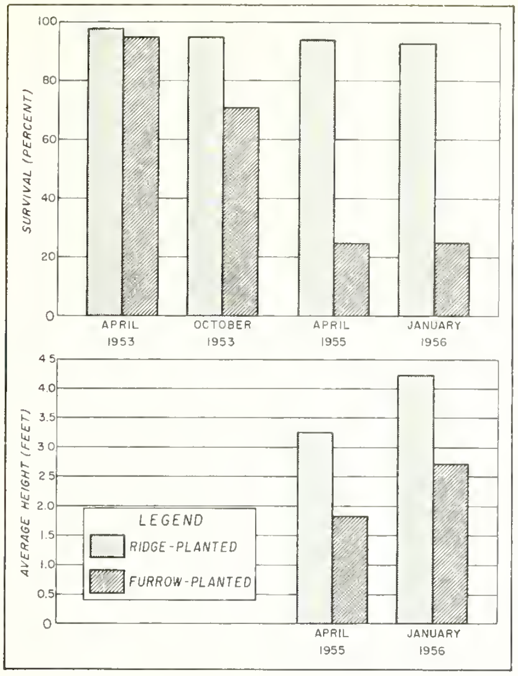


Figure 47.--Ninety-six percent of ridge-planted seedlings survived the first year; they averaged 51 inches at the end of the third year.

During the first year, the survival of ridge and furrow seedlings was 96 and 71 percent, respectively. By the end of the second year after planting, survival of the ridge-planted seedlings was 94 percent, compared with 26 percent for furrow-planted seedlings. This significantly different survival continued through the third year. Height growth of the seedlings in ridge positions was also impressive, being about $1\frac{1}{2}$ feet ahead of the furrow-planted seedlings at the end of both the second and third years.

Excessive rains occurring during the summer in this subtropical climate probably had much to do with the large differences in survival and growth. Water stood in the furrows for several prolonged periods during both 1953 and 1954.

Hardwoods Do Poorly on Abandoned Fields in Upland Areas

A study near Athens, Georgia, designed to screen species for planting possibilities, indicated at the end of the second growing season that criteria established for the Virginia-Carolina Piedmont region by Minckler and Chapman 1/ are equally applicable to the Georgia Piedmont, i.e.:

1. Yellow-poplar, black walnut, and black locust will not grow on abandoned old-field upland sites. These species should be confined to the extreme lower slopes, coves, and well-drained bottoms.

2. On slopes, ridges, and upland areas, loblolly pine and shortleaf pine will have better survival and early growth than hardwoods.

Southern red oak, northern red oak, chestnut oak, and scarlet oak were tested on the bottomland site. Although satisfactory survival was obtained (90, 94, 78, and 92 percent, respectively) and healthy seedlings resulted, none of these species exhibited height growth over 0.20 foot per year on unprepared sites. Indications are that more intensive culture will be needed for successful planting on the bottomlands.

1/ Minckler, L. S., and Chapman, A. G. Tree Planting in the Central, Piedmont, and Southern Appalachian Regions. U. S. Dept. Agr. Farmers' Bul. No. 1994, 40 pp., illus. 1948.

A further comparison points up the possible need for site preparation and other cultural measures. Yellow-poplar seedlings outplanted on the Georgia Piedmont with no preplanting or postplanting site preparation averaged approximately 9 inches in height at the end of the first growing season. Trees from the same shipment planted in a prepared field and fertilized and irrigated averaged 3 feet in height.

Cottonwood and Sycamore Show Excellent Promise for Planting in Piedmont Lowlands

Of the Georgia Piedmont land occupied by hardwoods, nearly half is lowland. These areas are the most productive and have the greatest promise for growing hardwoods. Furthermore, several lowland tree species, such as cottonwood and sycamore, show up better than any other species in hardwood planting experiments to date.

Figure 48 shows a 1-year-old plantation of cottonwood cuttings made by the Athens-Macon Research Center on the Watson Springs School Forest near Athens. The area was disc-harrowed the preceding fall, planted with cuttings at a 9x9-foot spacing, and cultivated twice during the growing season. Average height at the end of one season was 7 feet.

Figure 48.--One-year-old eastern cottonwood plantation. Cuttings were planted in January 1956. Eighty-eight percent of the cuttings rooted. Average height growth of the stems at the end of the first growing season was 7 feet. Ten percent of the stems were over 9 feet tall and maximum height growth was 10.8 feet.

In a first-year test of 1-year-old sprout sycamore cuttings set out by the Athens-Macon Research Center in both the fall of 1955 and spring of 1956, the larger cuttings showed a higher survival than the smaller. There was no significant difference in survival between spring and fall planting or between cuttings taken from different heights on the parent stem. However, the observations suggest that healthier top-growth is associated with cuttings closest to the root collar as well as with fall planting (fig. 49).

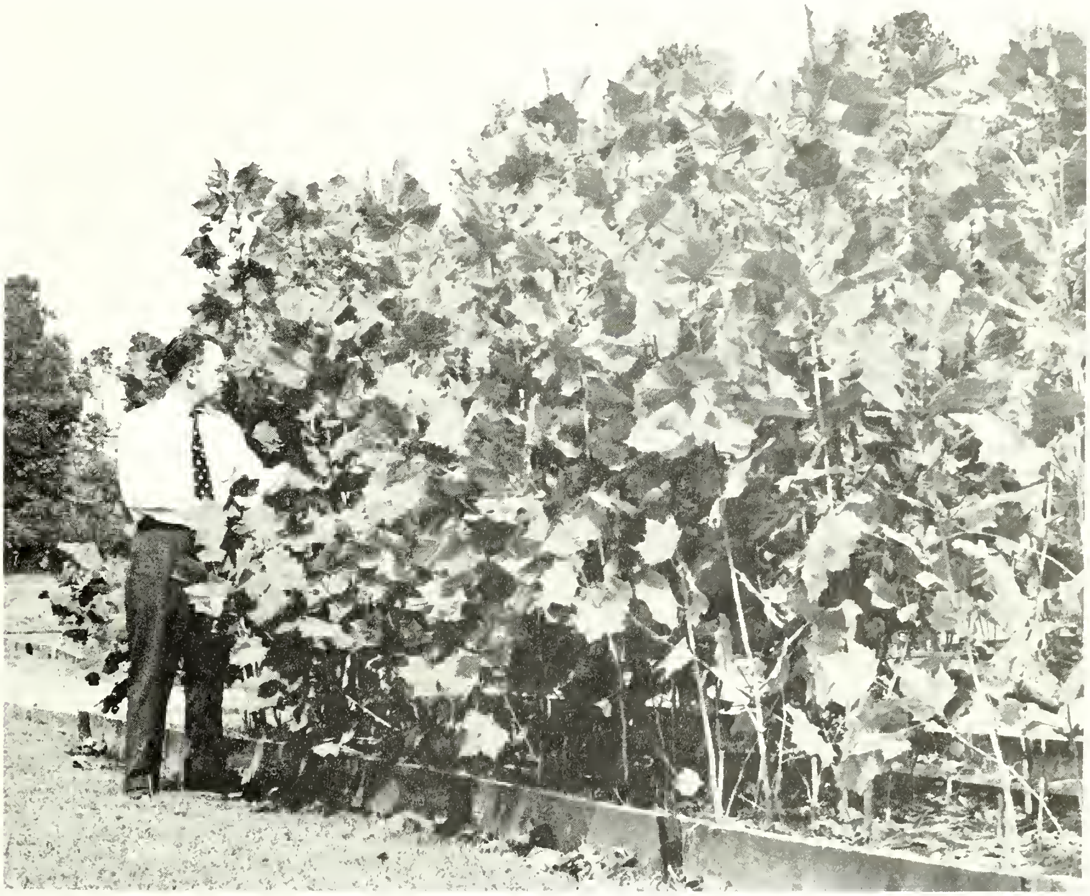


Figure 49.--Cuttings of American sycamore at the end of the first growing season. The best trials gave 65 percent survival and maximum height growth of 8 feet during the first growing season.

Survival of Plantings in Coastal Plain Bottomlands

A study at the Santee Research Center in South Carolina has tested for 3 years the suitability of various hardwoods and conifers for under-planting rundown bottomland hardwood sites, both with and without removal of shade. Of the five species most thoroughly tested, Shumard and cherrybark oak seemed particularly adaptable (table 6).

Loblolly pine has done well on cleared bottoms and terraces, while yellow-poplar and redcedar survived best on terrace sites. With the exception of loblolly pine, 1 year of shade tended to improve early survival of all planting stock.

Table 6.--Survival during first growing season, by species and treatment for 3 years of planting on first bottom and terrace sites

Species	Cleared		Not cleared		All sites
	Bottoms	Terraces	Bottoms	Terraces	
	Percent survival				
Yellow-poplar	44	88	31	94	64
Shumard oak	78	89	88	93	87
Cherrybark oak	72	82	84	89	82
Redcedar	28	74	28	77	52
Loblolly pine	87	92	76	79	84
All planting stock	62	85	61	86	--
Cherrybark oak acorns	34	34	22	30	30
Shumard oak acorns	34	40	22	33	32

Natural Regeneration

Despite the vast increase in forest planting in the South, the great majority of areas cut over for a long time in the future will have to be regenerated naturally. Yet the Timber Resource Review shows that more than half the southern pine area recently cut over failed to make the high productivity class because of inadequate stocking of preferred species in the next crop. Pine land is being lost to usually less productive hardwoods at a very rapid rate--faster in most areas than it is being planted. To help reverse this trend, the Station has gathered much useful information on seedbed requirements, seeding habits, seedling growth, and methods needed to re-establish pine or other valuable species by natural seeding.

The Important Place of Seedbed Scarification in the Regeneration of Shortleaf Pine on the Piedmont

Shortleaf pine is considered difficult to regenerate on the extensive areas it occupies on the upper Piedmont. At the Piedmont Research Center a study in cooperation with the Duke Power Company shows the important place of scarification in improving the seedbed for germination and reducing the hardwood competition to favor growth of seedlings. Examination of three test areas in North and South Carolina disclosed seven times more seedlings at the end of 1 year on scarified than on intervening unscarified strips. Correspondingly,

the percent stocking was four times greater on prepared sites (fig. 50). At the end of the first growing season, scarified strips were only one-fourth covered with medium or heavy brush competition, whereas the unscarified strips were two-thirds covered. Scarification deserves a great deal more use than it has had up to now as a means of perpetuating shortleaf pine.

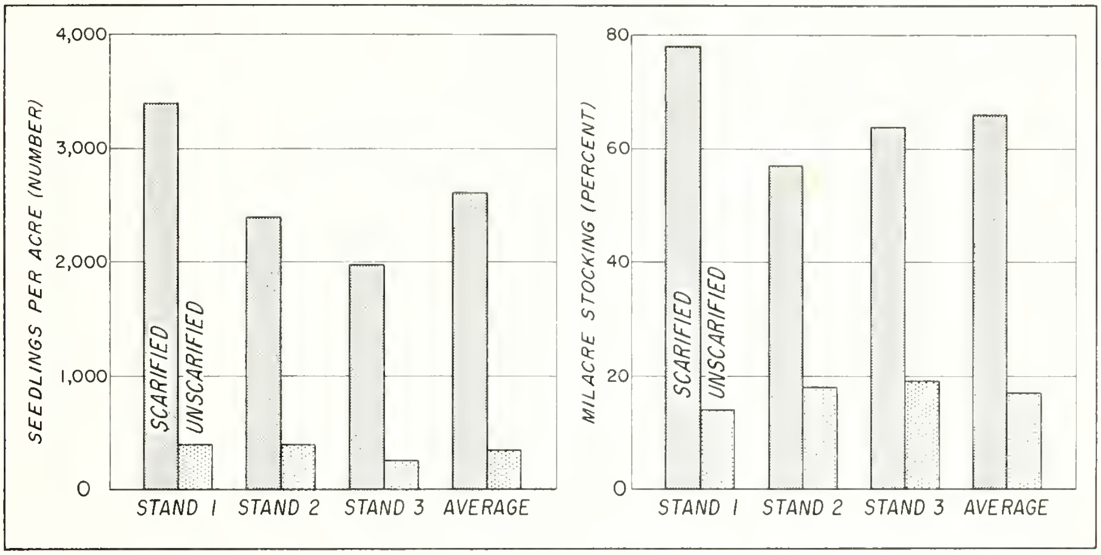


Figure 50.--Number of seedlings per acre and percent stocking on scarified and unscarified areas in Piedmont shortleaf pine stands.

Good Seed Production From a Young Stand of Loblolly Pine

A 10-year record of loblolly pine seedfall in a 35- to 45-year-old stand on the Santee Experimental Forest, Berkeley County, South Carolina, indicates that young stands under management are capable of producing seed abundantly. Seed crops ranged from 200,000 to 1,400,000 seeds per acre, averaging about half a million (fig. 51). Viability followed the general pattern of production, being lowest in the poorest seed year and highest in the best. Average viability was good, amounting to 66 percent for the 10 years.

The timing of the seedfall from month to month was also determined over the 10-year span (fig. 52). The results suggest that when a harvest cutting and natural regeneration are anticipated, any necessary seedbed preparation should be completed about November 1 and cutting delayed until about January 1 for maximum utilization of a seed crop.

Loblolly Pine Reproduction Survives and Grows Under Varying Densities of Overwood

The shelterwood method shows considerable promise for loblolly pine in the Piedmont, since it provides almost certain success of reproduction while assuring a reasonable income during the regeneration period. In the lower Piedmont, fully stocked stands of advance reproduction survive and grow under

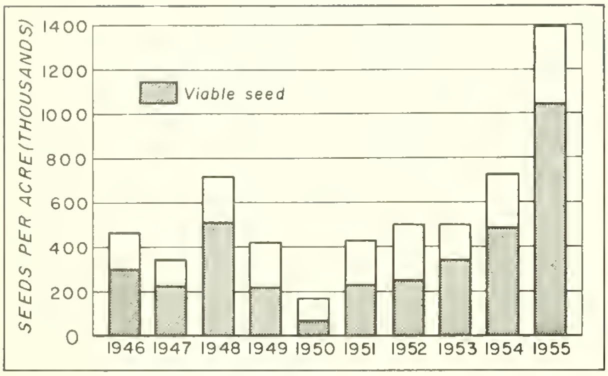


Figure 51.--Ten-year record of loblolly pine seedfall in a 35- to 45-year-old stand, Santee Experimental Forest.

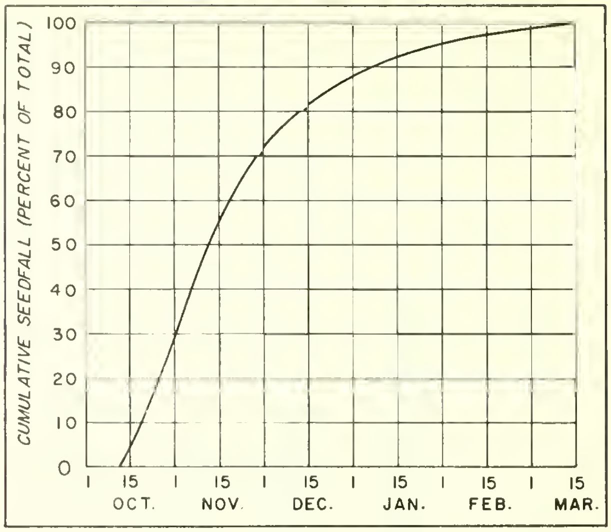


Figure 52.--Average rate of loblolly pine seedfall as determined from 10-year record in a small sawtimber stand, Santee Experimental Forest.

a wide range of overwood densities of loblolly pine. It has been shown on the Hitchiti Experimental Forest, near Macon, Georgia, that a relatively small amount of overwood markedly reduces the height growth of understory seedlings, compared with that of free-growing seedlings. However, a rather large additional increase in overwood density is required to bring about a significant additional reduction in seedling height growth. Thus, under the shelterwood method of regeneration, considerable leeway can be exercised in the amount of overwood left.

The study also shows that level of shade ranks with overwood density as a major factor affecting the growth rate of loblolly pine seedlings (fig. 53). A stand with a high canopy level is much more favorable to the growth of the pine seedlings than is a stand of comparable density with a low canopy level.

Slash Pine Seeding Habits

Seedfall studies in 40-year-old slash pine stands in the Olustee Experimental Forest from 1950 to 1955 provided some helpful information for forest managers using natural seeding for stand regeneration. Information of this kind has been particularly scanty for slash pine.

Two good seed years occurred during the 5 years of observation. Seed quality varied with the size of the seed crop, ranging from 34 percent sound seed in the poorest seed year up to 77 percent in the best seed year. About 80 percent of the total seedfall consistently occurred in October, and seed quality was highest during the period of heaviest fall. At least 50 percent of the sound seed fell within 50 feet of the source and 90 percent fell within 150 feet of the source, showing that effective quantities of slash pine seed are not carried far.

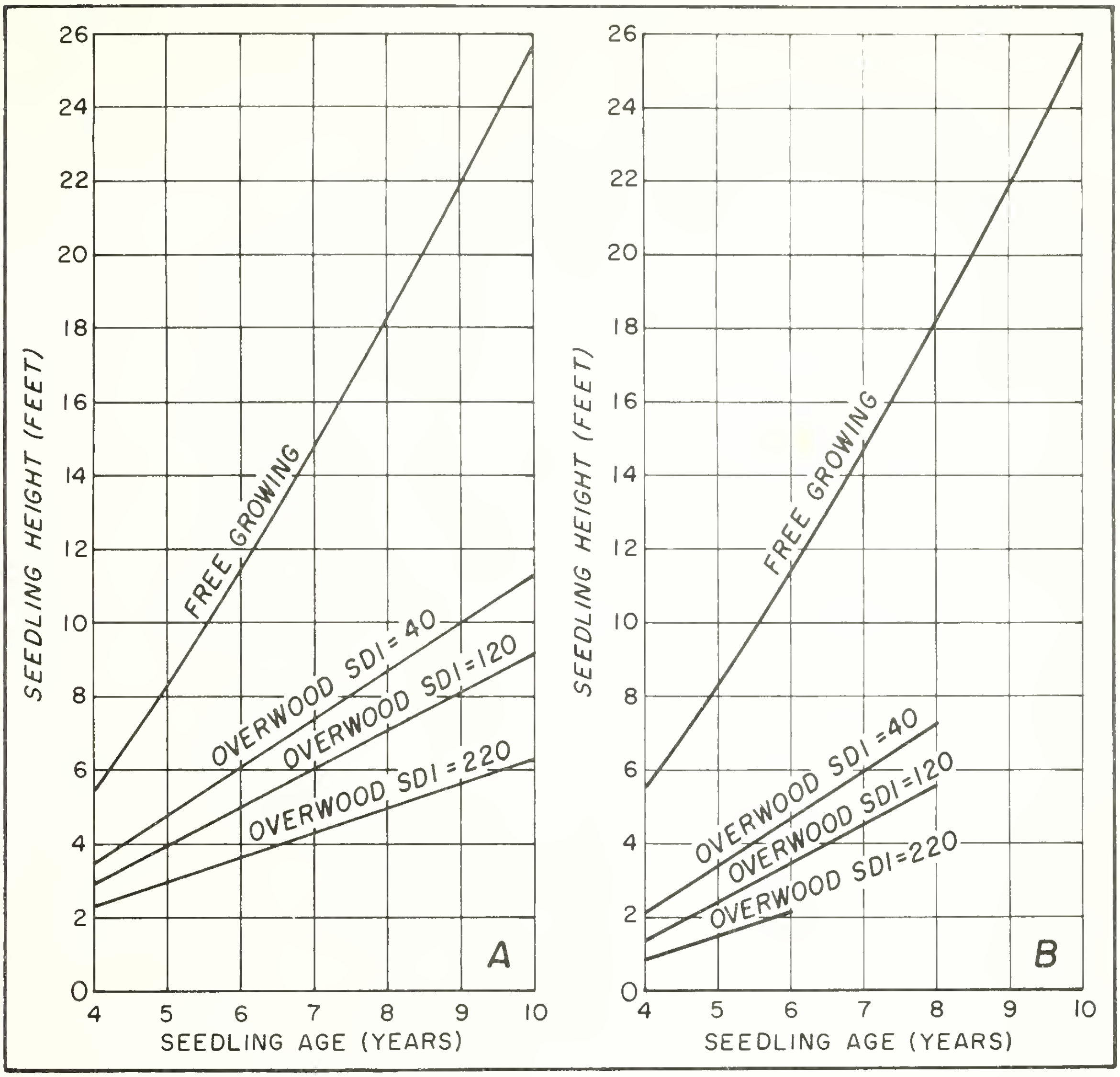


Figure 53. --Comparison of understory seedling heights at various ages and overwood densities with that of free-growing seedlings. A, At a high (40-foot) shade level. B, At a low (20-foot) shade level.

A comparison of well-stocked and partially cut stands showed that increased amounts of seed per tree were produced three growing seasons after cutting. Although the partially cut stand had only about one-fourth as many trees of cone-bearing size, seed production in 1952, the first effective year of release, was nearly as high as in the well-stocked stand (table 7).

These findings show that seedbed preparation should be completed before October if the seed is to be used most efficiently; that seed trees should not be spaced more than 150 feet apart, no matter how fruitful they may be; and that partial cutting three or more years before the harvest cut will result in increased amounts of seed when it is needed.

Table 7.--Effect of release on the production of slash pine seed

Seed year	Sound seed per acre	
	Well-stocked stand	Partially cut stand [1]
	Thousands	Thousands
1950-51	64.5	18.0
1951-52	8.0	2.0
1952-53	117.0	97.0
1953-54	0.5	11.0
1954-55	2.5	2.5

[1] Cutting was done in 1949. The partially cut stand had 11 trees 10 inches d.b.h. and larger per acre and the well-stocked stand had 47.

Stand Improvement

Because of the limited market for poorer hardwoods in the Southeast, these trees are usually left when pine and the better hardwoods are cut. Since the Forest Survey started in the Southeast in the 1930's, the area in hardwoods has increased and the area in the more productive pine types has decreased. For example, latest survey figures for North Carolina show that 2.8 million more acres are in hardwoods now than in 1937, and 1.6 million acres less are in pine. While some of the hardwood increase is on land best suited for hardwoods, much of it has taken place where hardwoods are of poor quality and grow slowly. Thus, hardwood cull volume has increased 36 percent since 1937. Stand improvement measures are being applied on an ever-increasing scale to arrest this trend in southern woodlands. The search for better methods is continuing, and appreciable progress has been made during the past year.

Pruning Sycamore

High values in hardwoods are generally associated with large size and clear wood. Hence, wide spacing and pruning may be needed in the future management of certain hardwood species to grow high-quality lumber and veneer in a reasonable time.

A pruning study installed in 1948 in a 9-year-old natural stand of open-grown sycamore on the Bent Creek Experimental Forest near Asheville, N.C., has shown that the treatment had no serious effect on the growth and vigor of the trees (fig. 54). Pruning to 12- and 18-foot heights caused only a slight

Figure 54.--Seventeen-year-old natural stand of sycamore on the Bent Creek Experimental Forest. The three trees in the foreground are part of the pruning study and have been marked with bands of white paint; the tree on the left was pruned up to 12 feet in 1948 and on up to 18 feet in 1951; the tree in the center was pruned to 18 feet in 1948 and on up to 26 feet in 1951; and the tree on the right is a control tree, not pruned.

reduction in diameter growth, both at breast height and at the top of the first log. At the same time, initial pruning resulted in an increase in height growth of about 6 inches per year for the first 2 years after pruning. A similar effect on height growth has been reported for other hardwoods.

Three years after the initial pruning, the same trees were given a second pruning, from 12 feet to 18 feet in one class and from 18 feet to 26 feet in the other. Following this second pruning in 1951, about 5 cords of pulpwood thinnings per acre were removed in order to maintain a rapid rate of growth. Five years after the last pruning, growth rates of both pruned and unpruned trees were about the same.

Pruning wounds healed in 1 to 2 years; while increasing the amount of clear wood growth, pruning reduced sapwood decay by hastening healing where dead branches were severed. Epicormic branching--never serious--has now entirely disappeared.

At 17 years of age the stand averaged over 9 inches d.b.h. and 70 feet in height. It carried a volume of 20 cords per acre, or 2,310 board-feet plus 12 cords of pulpwood. It is expected that ingrowth and growth of the present sawtimber trees will give this stand a volume of 10,000 board-feet per acre by the time it is 22 years old (fig. 54).

Control of Undesirable Trees and Shrubs in the Mountains

Results at the end of 2 years in the control of undesirable mountain species show that for small size classes basal spray with 2, 4, 5-T in oil (4 pounds acid equivalent in 20 gallons of solution) was most effective in crown kill of laurel (85 percent), red maple (73 percent), and oak (62 percent). There was less sprouting following basal spray than after any other treatment. Basal spray was not effective, however, in crown-killing certain other species, such as rhododendron (15 percent), sourwood (20 percent), and hickory (45 percent).

For large trees, the best treatment was 2, 4, 5-T in oil (4 pounds acid equivalent in 50 gallons of solution) applied in ax frills. This technique showed a crown kill of 86 percent when oaks, hickories, sourwood, and red maple were averaged. Ammate in cups, though ranking second among treatments in over-all effectiveness of crown kill, proved a poor silvicide for hickory, where the crown kill was only 43 percent. Ammate was, however, the most effective treatment for sourwood.

Results of Chemically Treated Scrub Oak in the Sandhills

A study in the chemical control of scrub oak on the Sand Hills State Forest in cooperation with the South Carolina Commission of Forestry has shown after 2 years that Ammate in notches, stump spray with 2, 4, 5-T, and basal spray with 2, 4, 5-T (20 pounds acid equivalent per 100 gallons of

solution) are all effective treatments for small stems $\frac{1}{2}$ to 4 inches in diameter. The best season of treatment varied with the method of treatment, as shown in figure 55. Ammate in combination with the Cornell tool proved ineffective. Resultant sprouting was extensive.

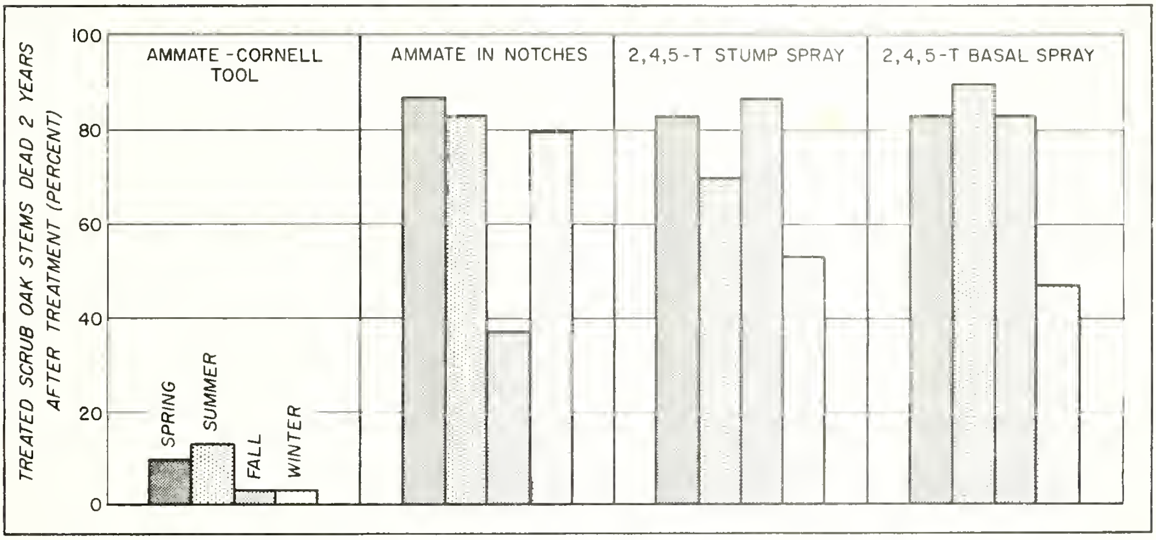


Figure 55.--Small stems of scrub oak dead 2 years after treatment, according to method and season of treatment.

Prescribed Summer Fire in the Control of Lowland Hardwoods

Hardwood and shrub understories on loblolly pine sites in the Coastal Plain can be kept to a controllable size by periodic burning. But more drastic treatment may be needed temporarily at the regeneration period to favor pine reproduction by reducing the number of hardwood rootstocks. This might be done with silvicides or with fire. A test at the Santee Experimental Forest near Charleston, S. C., shows that prescribed summer fires in successive years accomplish this objective (fig. 56). After 5 years' treatment, only 31 percent of the hardwood rootstocks remained alive. While black gum and the oaks proved most tenacious, 95 percent of the myrtle and 79 percent of the sweetgum were dead.

It is now becoming evident that hardwood mortality is similar on annually and biennially burned plots, a fact not apparent from the first 2 years of study. Detailed soil analyses are now being made at the laboratory of the Piedmont Research Center to learn what effects these drastic treatments may have on the soil.

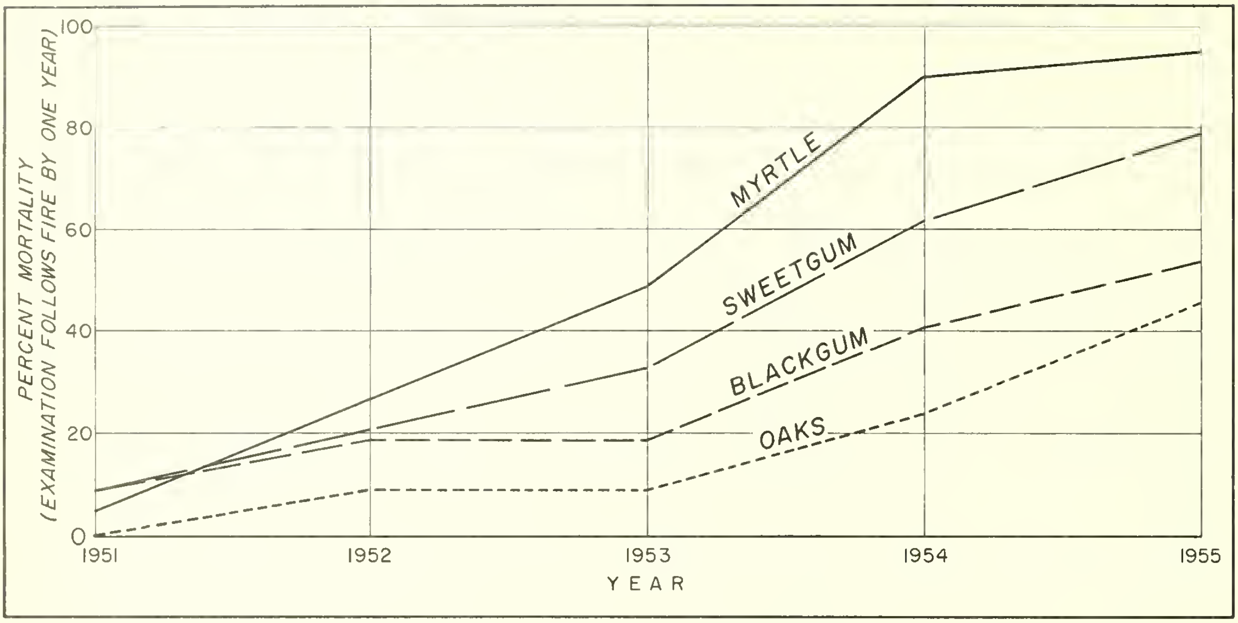


Figure 56.--Mortality of understory hardwoods subjected to successive summer prescribed fires in 40- to 50-year-old loblolly pine stands.

Silvics

Climatic Factors Associated with the Distribution of Loblolly Pine

The basic relationship of climatic factors to the distribution of loblolly pine was revealed in a study by Duke University in cooperation with the Station. At the outset of the study, it was necessary to compute up-to-date monthly temperature and precipitation means for several hundred stations in and near the southern pine region. This information was published in Station Paper 56 because of its value in basic research in genetics and silvics.

The new means were then used in a discriminant function analysis of the relation of loblolly pine distribution to seasonal variation in temperature and rainfall and published by Harold W. Hocker, Jr. in Ecology, October 1956. The study showed that during both winter and summer, the loblolly pine range has a greater number of days with rain and a greater frequency of effective amounts of rain (more than 0.50 inch) than the area immediately outside the range. It also has a higher average temperature in winter. In spring and autumn, the weather inside and immediately outside the range is much more similar. The northern extension of the species is probably limited mainly by low temperature, which may reduce absorption of moisture by roots as well as damage plant tissues directly. The western extension is limited mainly by insufficient rains.

This research resulted in an equation which can be used in determining whether or not the climate in another section of the country or the world might be favorable to the growth of loblolly pine. It also resulted in a map of values indicating the apparent climatic favorability for loblolly pine in different portions of the South (fig. 57). These values will probably be useful additions to soil-site prediction studies to correct for the additional effect of climate. Earlier studies have already shown that predictions of loblolly pine site in the Gulf states from soil are inaccurate unless climatic factors are included. The discriminant values plotted on the map should indicate the area most favorable for the growth of loblolly pine. The area in the Gulf coastal region from western Mississippi eastward is one of generally high discriminant values and relatively high site index for the species.

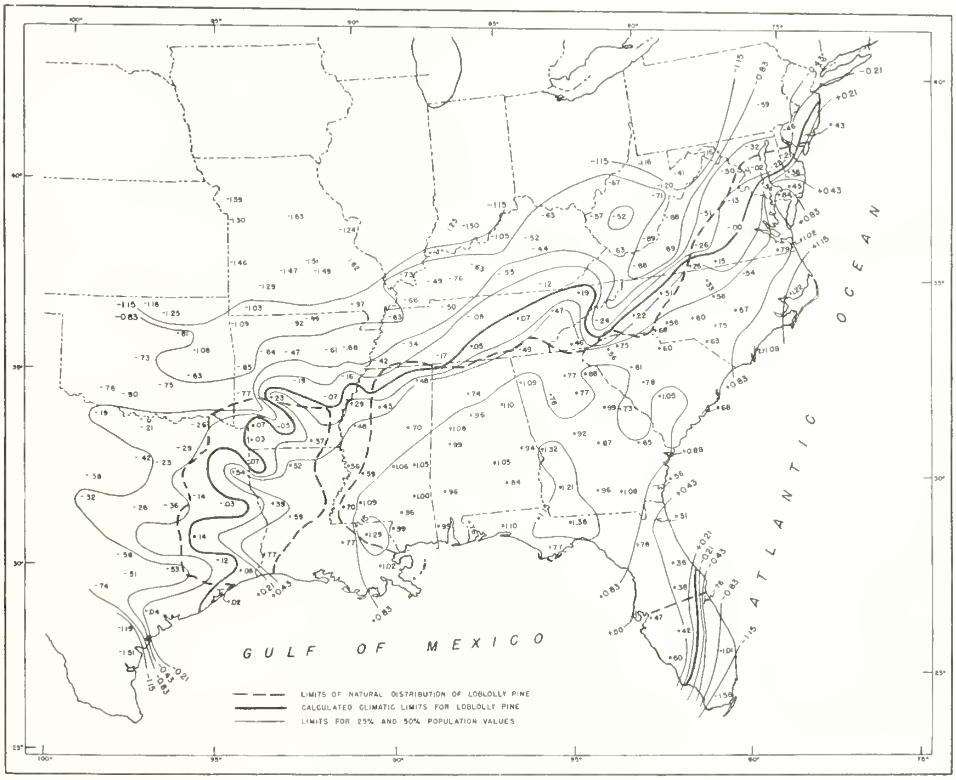


Figure 57.--The natural distribution of loblolly pine in comparison with the distribution based on favorable precipitation and temperature. Values on the map indicate relative favorability (plus numbers) or unfavorability (minus numbers) at the location of each weather station.

Finally, the discriminant values for areas on the border of the loblolly pine region should show the relative possibilities for extending the range of this species by planting. The data indicate that there are three areas adjacent to the present range where the climate is very similar to that within the range. They are (1) southeastern New Jersey, (2) the Tennessee Valley north to Knoxville, and (3) southwestern Florida. However, considering climate alone, no appreciable northward extension of the loblolly pine seems feasible.

Variability of climate within the loblolly pine region is most important to geneticists and silviculturists working with this far-flung species. The extent of this geographic variation within the range is shown graphically in figure 58.

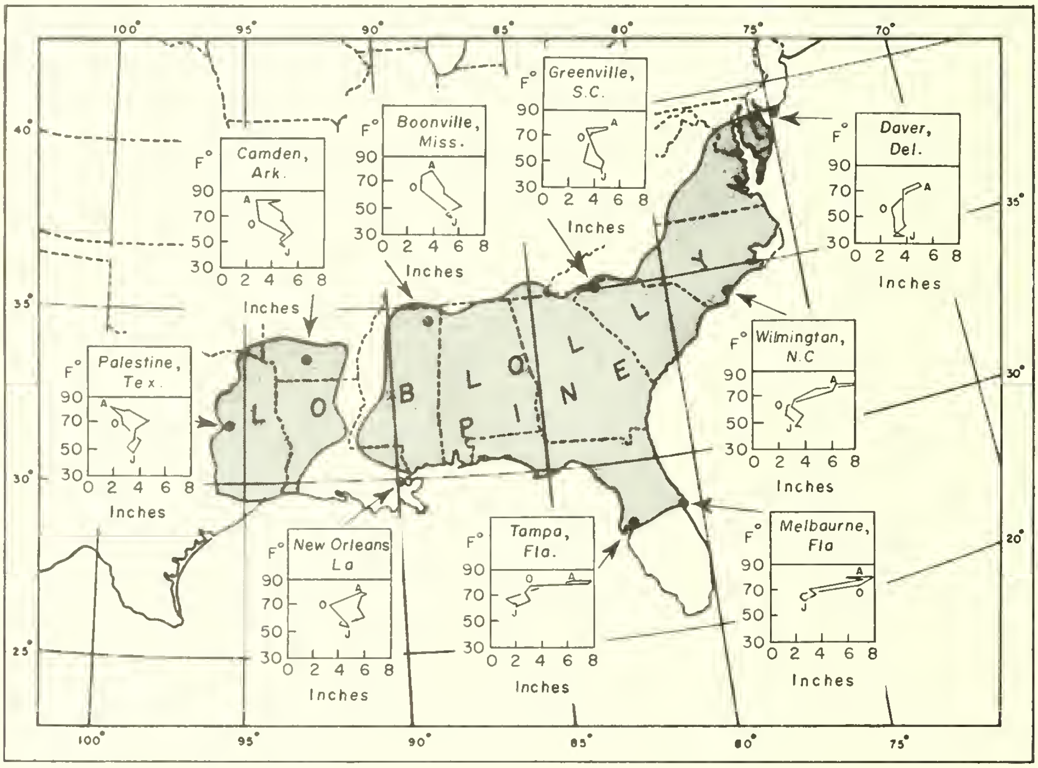


Figure 58.--Range in climatic types throughout the loblolly pine region. The climographs illustrating the climatic patterns consist of mean monthly temperature plotted over mean monthly rainfall and a line connecting the months in sequence. The letters J, A, and O, identify the months of January, August, and October.

Site Prediction Test in a Slash Pine Plantation

The increasing amount of planting being done has created a parallel interest in methods of predicting growth in plantations. Recognizing that site index curves and yield tables for natural stands cannot be used in plantations, R. L. Barnes and C. W. Ralston studied the relation of soil properties to the growth of slash pine plantations in Florida ("Soil Factors Influencing the Growth of Slash Pine Plantations in Northeast Florida," University of Florida School of Forestry Research Report No. 1) and found that site quality for slash pine could be accurately estimated by measurement of two soil features: depth to mottling and depth to a fine-textured horizon.

A test of the Barnes and Ralston method was made in one section of the middle Coastal Plain of Georgia by the Georgia Forestry Commission, the University of Georgia, and the Southeastern Forest Experiment Station (fig. 59). This test showed that depth to mottling was closely correlated to depth to a fine-textured horizon. Therefore, depth to mottling alone, as given by Barnes

Figure 59.--Influence of soil factors on the growth of slash pine in different parts of the same 17-year-old plantation. Above, good growth on an area with fine-textured layer $7\frac{1}{2}$ feet below the surface. Here, averages per acre are height 46 feet, d.b.h. 5.9 inches, basal area 97.12 square feet, and site index was 60 feet at 25 years. Below, poor growth on an area of deep sand having no fine-textured layer within 10 feet of the surface. Here, averages per acre are height 28 feet, d.b.h. 3.8 inches, basal area 43.11 square feet, and site index was 39 feet at 25 years.

and Ralston, was used to predict site quality (height of trees at 25 years) in Georgia. The site quality estimated according to this method agreed closely with the observed site quality on all soils except those with a depth to mottling of less than 10 inches. However, such shallow soils make up only a small portion of the total planted area.

A more detailed study of the prediction of slash pine plantation growth from soil properties is now in progress.

Farm Woodland Management

Individual farm woodlands may approximate only 40 to 50 acres each, but they represent 60 percent of the forest land in the Southeast. Accordingly, farm woodland problems are particularly important.

Six-Year Operation of Farm Woodlot Near Cordele

Six years of management on the 49.06-acre woodlot of longleaf-slash pine near Cordele, Georgia, has returned a total of $4,280.80 in stumpage its equivalent, regardless of the fact that practices are intentionally geared to the level of a farmer who sells his product on the stump (table 8).

Table 8.--Six-year returns from various products

Product	Return
	Dollars
Sawtimber (2 cuts)	2,986.81
Gum, net (4 years)	772.26
Pulpwood (1 cut)	521.73
Total	4,280.80
Mean annual (gross acre)	14.54
Mean annual (net acre) 1/	19.27

1/ Only 37.02 acres as yet carry stands in merchantable sizes.

The returns from the two cuts actually apply to a 10-year period because cutting is scheduled at 5-year intervals. Even on this basis, however, the returns were very good.

At the end of the period, residual stands contained 7,047 board-feet of pine sawtimber, together with minor quantities of pulpwood valued at $199.02 per acre of merchantable timber.

First Cut Made on the Chesterfield Woodland

The first management cut on the Chesterfield farm woodland of 46.9 acres, located in the transition zone between the Piedmont and the mountains, has been completed. This is a joint effort of the Furniture, Plywood, and Veneer Council of the North Carolina Forestry Association, the Duke Power Company, and the Southeastern Forest Experiment Station.

The operation removed as much low-quality hardwood timber as possible while providing an operable cut. Returns per acre were $31.91 stumpage, or $135.72 delivered at market. The improvement cut removed slightly over one-third of the basal area and nearly one-third of the volume. The residual stand averages 3,640 board-feet, International $\frac{1}{4}$-inch scale, plus 10.8 cords of pulpwood.

Financial Aspects

Levels of Growing Stock in Appalachian Hardwoods

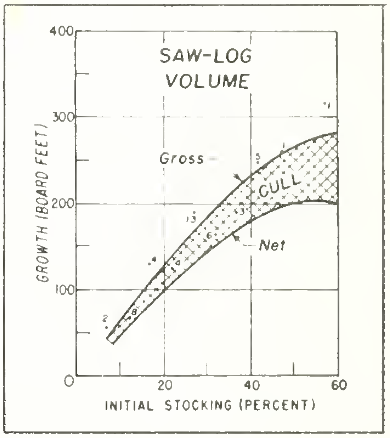


Figure 60.--Annual board-foot increment of old-growth Appalachian hardwoods during the 15-year period, 1937-1952, in relation to initial stocking.

In 1937, old-growth Appalachian hardwoods in the Bent Creek Experimental Forest were given a series of formative cuts to get information on growth per acre and regeneration obtained under different amounts and kinds of residual growing stock. Ten 1-acre plots were devoted to each of five levels of residual stocking consisting of clear-cutting, residual volumes of 1 to 6 thousand board-feet per acre, and uncut check stands with 7 to 10 thousand board-feet per acre.

Remeasurement of the stands 15 years after cutting showed that the maximum net growth of 205 board-feet per acre annually was attained with a starting volume of 7,200 board-feet, or a density of 55 percent of maximum (fig. 60). Maximum annual value increment of $3.15 per acre was obtained with an initial stand value of $70.00 (fig. 61). Average annual diameter growth was about 2 inches in 10 years for the less desirable species and 3 inches in 10 years for yellow-poplar and northern red oak.

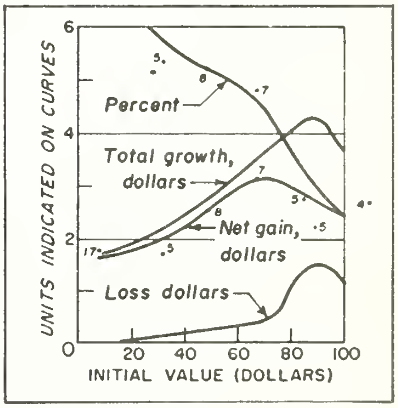


Figure 61.--Annual value changes per acre, 1937-1952, in relation to the value of the growing stock left after cutting.

The distribution and density of reproduction was best on the more heavily cut areas, but all cut areas were well regenerated in 15 years. The initial advantage of light-seeded species in the larger openings was reduced somewhat by sprouting, and the new stand is of mixed seed and sprout origin.

Detailed results of the study have been published in the Journal of Forestry, Volume 54(2), pages 106-114, "An Early Test of Levels of Growing Stock in Appalachian Hardwoods," by W. G. Wahlenberg.

Tree Improvement and Genetics

The expanded artificial regeneration program in the Southeast, undreamed of a decade ago, has aroused a compelling plea on every hand for genetically superior stock. In recognizing tree seed as a primary factor in the success of eventual harvest, timber owners are following a technique that has improved row crops on farms for many years.

Progress in the Selection of Superior Southern Pine

Cooperative work in the selection of fast-growing, well-formed strains of southern pine was undertaken with the Ida Cason Callaway Foundation of Hamilton, Georgia, in 1950. It soon became apparent that when they are random-pollinated by the wind some of the selected, superior mother trees transmit their fast-growth traits to their progeny, whereas others do not. Thus, major emphasis so far has been on progeny testing. These test plantings repeated yearly for most progeny groups now show that seedlings from certain plus trees of slash, loblolly, and shortleaf pine consistently grow as much as 40 percent faster than seedlings from average parents.

Individual loblolly and slash pine trees also vary widely in fusiform rust infection, so that apparently resistant trees can be selected. Seedlings from such selected slash pine mother trees have much less rust infection than seedlings from unselected trees, at 4 years of age. In loblolly pine, large differences in rust occurrence among the groups of seedlings from individual selected trees indicate that resistant strains may be developed by selection.

"Super" Slash and Loblolly Pine Seedlings Average Taller Than Controls After 2 Years

Nurseries offer exceptional opportunities for finding inherently fast-growing trees because selections can be made from among millions of seedlings at the same age growing under similar conditions. Such "super" seedlings must be observed in plantations for a number of years to determine whether they will maintain their faster growth rate, which would mean that it is hereditary.

Preliminary results of a slash and loblolly pine nursery selection study conducted near Macon, Georgia, in cooperation with the Georgia Forestry Commission show that at the end of 2 years in the field, "super" seedlings still average taller than the controls. Furthermore, the tallest seedlings are in the select group.

The select slash pine seedlings are 42 percent taller than the unselected controls, about the same difference observed after the first year. Loblolly pine in two blocks exceed controls by 31 and 36 percent, respectively; these differences are somewhat less than after the first year, when select seedlings averaged 43 percent taller than the controls.

In a similar study near Lake City, Florida, unselected slash pine seedlings averaged 2.13 feet in height after the third year, while selected seedlings averaged 2.94 feet in height, or 38 percent taller than the controls.

Superiority of Pine Seedlings in the Nursery Bed is Maintained 4 Years Later in the Field

Plantings made on the Santee Experimental Forest in 1952 indicate that 4 years after planting, large pine seedlings initially selected from nursery seedbeds continue their dominance and show markedly better early basal area and volume growth than nursery-run seedlings. The rule appears to hold equally true for slash, longleaf, and loblolly pines (tables 9 and 10).

Table 9.--A comparison of height of nursery-run and "superior" seedlings

Species	1-year-old seedlings		4-year-old seedlings	
	Nursery-run	Superior	Nursery-run	Superior
	Inches			
Longleaf pine	--	--	24.2	35.4
Loblolly pine	4.0	8.4	51.4	63.7
Slash pine	4.0	8.4	105.2	110.3

Table 10.--A comparison of nursery-run and "superior" seedlings in terms of basal area and volume

Species	Average basal area per tree		Average volume per acre	
	Nursery-run	Superior	Nursery-run	Superior
	Sq. ft. 1/		Cu. ft. 2/	
Longleaf pine	.0107	.0140	13.1	25.0
Loblolly pine	.0123	.0197	31.8	63.3
Slash pine	.0369	.0428	195.8	237.9

1/ 2 inches above groundline.
2/ Assuming 6x6-foot spacing, or 1,210 trees per acre.

Slash pine height growth for both classes of seedlings continues significantly better than either longleaf or loblolly, but within the various "superior" groups there appear to be no really outstanding trees on the basis of height growth only.

Time of Flowering and Seed Ripening in Southern Pines

The Committee on Southern Forest Tree Improvement has recorded approximate dates of pollen and seed ripening for slash, longleaf, loblolly, and shortleaf pines for the many stations throughout the natural ranges of the species. Similar data at a few stations have also been reported for the minor southern pines and the pines of the Appalachian Mountains. The results were published in Station Paper 72, "Time of Flowering and Seed Ripening in Southern Pines," by Keith W. Dorman and John C. Barber.

Slash pine pollen in Alachua County, Florida (Gainesville), was ripe January 21 (fig. 62) whereas in Dooly County, Georgia (Cordele), the ripening date was February 2. Longleaf pine in Alachua County, Florida, was ripe February 5, and in Hertford County, North Carolina (Murfreesboro), it wasn't ripe until April 16, or nearly 6 weeks later. Loblolly pine in Alachua County, Florida, was ripe February 25, and in Hertford County, North Carolina, April 4, about 6 weeks later. Shortleaf pine at Harrison County, Mississippi (Gulfport), was ripe about March 25, and at Hertford County, North Carolina, around April 25, or about 4 weeks later. Pond pine pollen ripened late in March in Florida but in northeastern North Carolina it wasn't ripe until the first week in May.

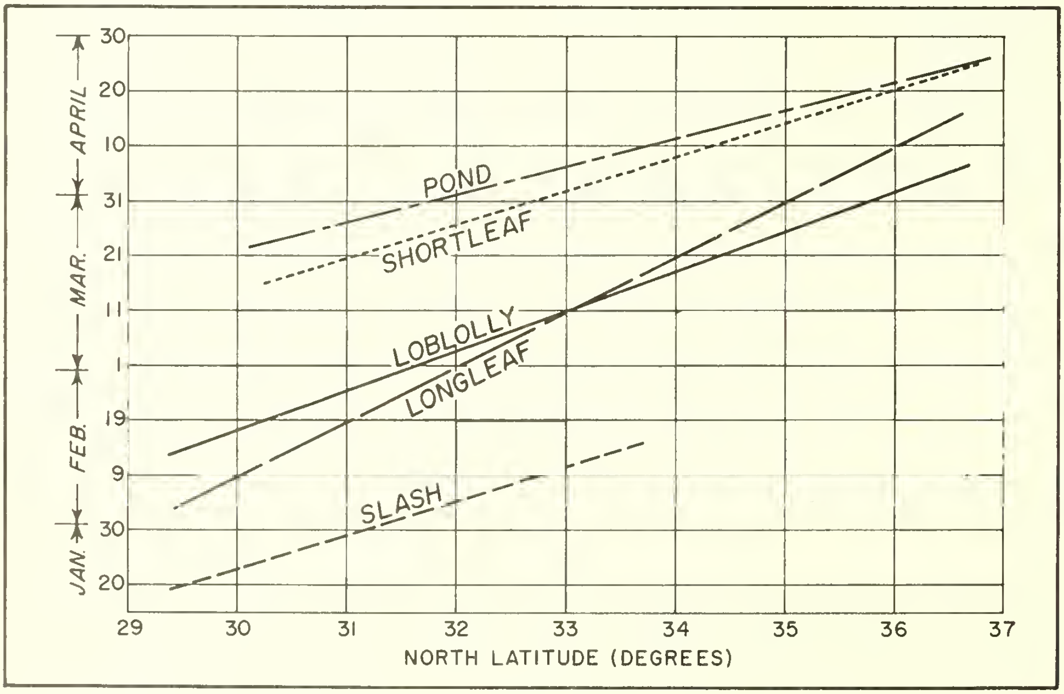


Figure 62.--Pollen ripening of principal yellow pines in relation to latitude.

Slash pine seed ripened about September 15, longleaf pine October 1 through 20, loblolly pine October 5 through 15, and shortleaf pine October 15 through 30. No strong relationship with latitude was indicated, but it might have been obscured by the difficulty of observing when seed was ripe.

Air-Layering of Cottonwood Proves Successful

Exploratory work on the vegetative propagation of cottonwood by air-layering has resulted in techniques which insure nearly 100 percent success (fig. 63). Hormodin 2 has given the most consistent and best rooting for layers left on the stems 6 weeks.

Figure 63.--Air-layers of eastern cottonwood. Techniques in air-layering eastern cottonwood have been developed such that nearly 100 percent of the air-layers form roots.

Although cottonwood is more easily propagated by cuttings, this species may serve as a guinea pig on which to work out certain basic problems connected with air-layering. For example, correlation between leaf surface and the rooting of air-layers has been obtained. The following tabulation shows the number of leaves left on the stem at the time of establishment and the ovendry weight of resulting roots weighed 7 weeks later.

Leaves (Number)	Root weight (Grams)
2	0.12
4	0.65
6	1.29
8	1.49
10	2.91

Racial Differences in Early Height Growth of Longleaf Pine

The Station is participating with most other forestry agencies in the South in the South-wide Pine Seed-Source Study sponsored by the Committee on Southern Forest Tree Improvement. One early result of this large new study is that the more easterly sources of longleaf pine show considerably faster early growth in plantations near Cordele, Georgia. Average heights at 3 and 4 years in the field are given for six seed sources in table 11. Some of the taller longleaf from the Georgia source at 4 years of age in the field are shown in figure 64.

Table 11.--A comparison of longleaf pine heights from six seed sources

Source	3rd year	4th year
	Feet	
Georgia	1.6	4.8
Alabama (Baldwin County)	1.2	4.8
Alabama (Claburn County)	0.7	3.5
Louisiana (Rapides)	0.8	3.2
Louisiana (Washington)	1.0	4.0
Texas	1.3	4.3
Mean	1.1	4.1

Figure 64.--Some of the taller longleaf pine produced from Georgia seed at the end of 4 years on the George Walton Experimental Forest.

Naval Stores

The decline in gum naval stores which started in 1949 is still continuing, and production is now less than 50 percent of the 1949 level. This decline is essential to avoid a surplus at the present time, but has not been taken as a signal to lessen research on production methods. On the contrary, such research should be intensified because production of wood naval stores is expected to decline rapidly during the next 10 years and an increase in gum naval stores will probably be needed to fill the gap. A future increase in gum production can be attained easily if production costs can be appreciably lowered.

Seed Orchards and Gum Orchards

Plantations of slash pine trees having potential gum yields twice that of average trees are now possible. In such plantations, gum yields can be doubled with no increase in production costs.

To make such plantations a reality as soon as possible, an irrigation system was installed in a 5-acre area to be used as the first orchard for producing seed of proven high-yielding genotypes. About 250 grafts of three selected genotypes will be made in 1957 and planted in this area. With fertilization and irrigation, seed production is expected within 8 to 10 years.

Concurrently, a gum orchard area has been set up with irrigation facilities in which fertilizer treatments and other suitable cultural methods will be compared to find which method gives greatest financial return per dollar invested during a 25-year rotation. This area will be planted in 1957 with rooted cuttings (air-layers) from trees of known yielding ability--both average and twice average.

Intensive Chipping Methods

A new labor-saving chipping method is now ready for commercial use. By making streaks 1-1/3 inches high every 2 weeks and treating them with 65-percent sulfuric acid, a normal season's yield can be obtained on only 12 streaks. For best results this short chipping season should start about April 15 and end about October 15. In this way the labor requirements for chipping can be reduced by 25 percent. This method is expected to be very useful for small woodland owners who produce gum as only one of several farm crops. However, it will probably have no appeal for the large producer who maintains a year-round crew of laborers.

For larger producers working on short-term leases, the intensive chipping methods described above can be used during the full season of 16 streaks or more for 2 successive years. With this treatment, yields 15 to 20 percent greater than those obtained with standard chipping can be obtained on slash

pine. On longleaf pine, however, the increase in yields is only 10 to 15 percent. This intensive treatment is not recommended for faces to be worked more than 2 years.

Equipment Development

Arrangements were completed for manufacturing the new and improved combination spray-puller for working high faces described in the annual report for 1955. This new tool is now in production and is made in three lengths.

A new tool for raising cups and tins installed with double-headed nails has been developed which appears to be better than any of the other tools now available for this purpose (fig. 65). The new raising tool will be tested on commercial operations during January 1957, and if performance is satisfactory a manufacturer will be sought.

Figure 65.--New tool for raising tins installed with double-headed nails on naval stores faces. Large 40d cup nails can also be extracted with this tool. Both types of nails can be pulled without bending and can be immediately redriven at the elevated position.

PUBLICATIONS

by

MEMBERS OF THE STAFF, INCLUDING COOPERATORS

Calendar Year 1956

BARBER, J. C., and REINES, M.
Forest tree improvement in Georgia. Ga. Forest Res. Council Rpt. No. 1, 11 pp., illus.

(A report of present status and progress of the Georgia Forest Tree Improvement Project.)

BENNETT, F. A.
Growth of slash pine plantations on the George Walton Experimental Forest. Southeast. Forest Expt. Sta. Paper 66, 21 pp., illus.

(Annual diameter growth averaged 0.53 inch up to 18 years, annual height growth averaged 2.9 feet, and annual cordwood growth averaged 1.2 cords per acre. Sawtimber volume was appreciable by 15 years of age under wider spacings. Seedlings interplanted 1 year after the original planting were suppressed.)

BENNETT, F. A.
Financial aspects of pruning planted slash pine. Southeast. Forest Expt. Sta. Paper 64, 9 pp., illus.

(Clear volume, cost, and net return from 2-phase pruning of slash pine trees. Average cost was 10-1/3 cents per tree and net return can be expected to range from $0.49 for a 9-inch butt log up to $3.85 for a 16-inch butt log.)

BENNETT, F. A.
Growth of planted slash pine on cutover lands and old fields. Jour. Forestry 54(4): 267-268.

(Height growth of planted slash pine seedlings in a cutover area was less than half that in an old field.)

BOYCE, J. S., Jr.
Sampling oak wilt trees with an increment hammer. Plant Dis. Rptr. 40(9): 822.

(Describes a quick and effective method of obtaining cultures from stemwood of oak wilt trees.)

BRENDER, E. V., and BARBER, J. C.
Influence of loblolly pine overwood on advance reproduction. Southeast. Forest Expt. Sta. Paper 62, 12 pp., illus.

(Describes the effect of overstory density and level of overhead shade on the height growth of loblolly pine seedlings. Under shade level of 20 feet and overstory density of 220 SDI, no seedling stands over 6 years of age were found.)

BRYAN, M. B.
A simplified method of correcting for slope on circular sample plots. Jour. Forestry 54(7): 442-445.

(Describes a method of slope correction which maintains the circular shape of plots on the slope, but adjusts the radius to maintain equal horizontal areas regardless of degree of slope.)

CAMPBELL, R. A.
Profits from pruning Appalachian white pine. Southeast. Forest Expt. Sta. Paper 65, 9 pp., illus.

(Pruning should be done only on good sites, where fast growth will offset compounding of interest. Trees should be pruned when they are from 4 to 6 inches in diameter.)

CAMPBELL, W. A., and VERRALL, A. F.
Fungus enemies of hickory. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. No. 3, 8 pp., illus.

(Discusses leaf diseases, bark cankers, rot cankers, wood rots, root rots, virus disease, and methods of preventing deterioration in hickory products.)

CHAPPELLE, D. E.
Thinning costs in planted slash pine. South. Lumberman 193(2417): 246-247. Dec. 15.

(Twenty percent more man-hours were required per cord produced in selection thinning than in alternate-row thinning.)

CLEMENTS, R. W.
Double-headed nails for attaching naval stores tins. Naval Stores Rev. 65(10): 15. Also in AT-FA Jour. 18(4): 6.

(Gives specifications for double-headed nails found most suitable in working trees for naval stores.)

CLEMENTS, R. W.
New shorter hook for acid sprayer. AT-FA Jour. 18(8): 18. Also, with title New "shorty" hook for acid sprayer, Naval Stores Rev.66(3): 7.

(New short hook facilitates handling of acid spray bottle and reduces danger of injuries to thumb and fingers.)

COOPER, R. W., and PERRY, J. H., Jr.
Slash pine seeding habits. South. Lumberman 193(2417): 198-199. Dec. 15.

(A partially cut, 40-year-old slash pine stand produced nearly as much seed three growing seasons after cutting as a well-stocked stand of the same age, although the latter had four times as many cone-bearing trees.)

CRUIKSHANK, J. W.
The forest survey in Virginia. Va. Forests XI(1): 8-9, 19.

(Explains forest survey, how the inventory is made, kind of information obtained, and use of forest survey information.)

CRUIKSHANK, J. W., and McCORMACK, J. F.
1955 pulpwood production in the South. Southeast. Forest Expt. Sta. Forest Survey Release 47, 29 pp., illus.

(Cords of pine, hardwood, and chestnut pulpwood produced by state, forest survey unit, and county; also change between 1954 and 1955 for pine and hardwood, by state.)

CRUIKSHANK, J. W., and McCORMACK, J. F.
The distribution and volume of hickory timber. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. No. 5, 12 pp., illus.

(Net volume of hickory sawtimber amounts to 24 billion board-feet. Volume given by states, tree diameter, and log grades.)

DEMMON, E. L., and BRIEGLEB, P. A.
Progress in forest and related research in the south. Jour. Forestry 54(10): 674, 676, 678, 680, 682, 687, 688, 690, 692.

(Summary of pioneer studies, establishment of formal research in 1921, the rise of cooperative studies, and description of principal accomplishments.)

DOOLITTLE, W. D.
Pruning sycamore. South. Lumberman 193(2417): 222-223. Dec. 15.

(Pruning wounds healed over in 1 or 2 years, and live-branch wounds developed little or no decay. Healing of dead-branch wounds arrested sapwood decay.)

DORMAN, K. W.
Genetics in relation to forest management. Iowa State College, School of Forestry, Ames Forester 43: 17-19.

(Knowledge of variation and heredity in trees can be applied whenever new stands are established and when intermediate cuts are made.)

DORMAN, K. W.
Progress in the selection of superior strains of southern pines. (Abs.) Assoc. South. Agr. Workers Proc., pp. 151-152.

(Variations in growth rate, fusiform rust infection, and crown width among progeny of superior mother trees indicate that important traits are strongly inherited and selection of superior types is possible.)

DORMAN, K. W.
Publications on forest genetics, Southeastern Forest Experiment Station. Southeast. Forest Expt. Sta. Paper 63, 18 pp.

(Annotated list, 1939 through 1955.)

DORMAN, K. W., and BARBER, J. C.
Time of flowering and seed ripening in southern pines. Southeast. Forest Expt. Sta. Paper 72, 15 pp., illus.

(Approximate dates of pollen and seed ripening for slash, longleaf, loblolly, and shortleaf pines for many locations throughout the natural ranges of the species; similar data for minor southern pines and the pines of the Appalachian mountains.)

DOYLE, H., and TARAS, M. A.
Mismanufactured hardwood lumber--amount received at North Carolina furniture plants. South. Lumberman 192(2397): 32. Feb. 15.

(Almost 10 percent of 4/4 lumber received at 10 North Carolina furniture plants by truck in 1955 was miscut.)

ENGLERTH, G. H., BOYCE, J. S., Jr., and ROTH, E. R.
Longevity of the oak wilt fungus in red oak lumber. Forest Science 2(1): 2-6. Also, with title Oak wilt fungus can be killed by steaming or kiln-drying, South. Lumberman 192(2400): 46. April 1.

(Considering a log storage period of 6 weeks from the time of cutting, the oak wilt fungus was still viable after 22 and 24 weeks respectively in air-seasoned and bulk-piled boards. Steaming and kiln-drying killed the fungus in lumber.)

FOSTER, A. A.
Diseases of the forest nurseries of Georgia. Plant Dis. Rptr. 40(1): 69-70.

(Common forest nursery diseases in Georgia, with comments about their control.)

FOSTER, A. A.
The effect of seedbed density on seedling production at the Georgia forest nurseries. Tree Planters' Notes 25: 1-3.

(More plantable seedlings of slash and loblolly pine can be produced at a seedbed density of 40 per square foot than at lower densities under Georgia conditions.)

FOSTER, A. A.
Fumigation of forest nurseries in the Southeast for control of weeds and root rot. Tree Planters' Notes 26: 1-2.

(The uses of ethylene dibromide, methyl bromide, and Vapam in forest nurseries are described.)

FOSTER, A. A.
Opening case-hardened southern pine cones. Jour. Forestry 54(7): 466-467.

(A method of reclaiming seed from immature pine cones that have failed to open.)

FOSTER, A. A., and HENRY, B. W.
Nursery control of fusiform rust demands careful spraying. Tree Planters' Notes 24: 13-15.

(Describes spraying conditions necessary to keep the incidence of fusiform rust low, emphasizing fungicides, nozzle pressure, and timing.)

FOSTER, A. A., CAIRNS, E. F., and HOPPER, B.
Modifications in soils of southern pine nurseries produced by fungicidal and nematocidal chemicals. (Abs.) Phytopath. 46(1): 12.

(Methyl bromide proved more effective than ethylene dibromide or D-D for fumigation of nursery soil in which pine seedlings developed severe root rot symptoms.)

GENTILE, A. C., and JOHANSEN, R. W.
Heat tolerance of slash and sand pine seedlings. Southeast. Forest Expt. Sta. Res. Note 95.

(One-year-old seedlings of sand pine and slash pine survived immersion of root systems in water bath of 120 degrees F., a promising treatment for destruction of nematodes on roots.)

GRANT, B. F., and PAGE, R. H.
Market for wood waste. Forest Farmer XVI(3): 8, 16.

(Use of wood shavings for poultry litter in the Georgia Piedmont.)

GRUSCHOW, G. F.
Curly pine. South. Lumberman 193(2417): 189-190. Dec. 15.

(Twenty-seven percent of the lumber cut from a 180-year-old shortleaf pine tree in the Bigwoods Experimental Forest had the rare and highly prized curly grain.)

GRUSCHOW, G. F.
Pond pine regeneration on grazed switch cane ranges. Southeast. Forest Expt. Sta. Res. Note 90.

(Grazing did not promote seedling establishment. Grazing damage to pond pine was generally confined to foliage below 8 feet in height.)

HALLS, L. K., and SOUTHWELL, B. L.
Piney wood gains: calf crop up, weaning weight on the increase. Southern Livestock Journal 16(1): 40-41.

(Beef production increased by: use of crossbred cattle, including some Brahman blood; adequate wiregrass forage during spring and summer; and a good feeding program in fall and winter.)

HALLS, L. K., HALE, O. M., and SOUTHWELL, B. L.
Grazing capacity of wiregrass-pine ranges of Georgia. Georgia Agr. Expt. Sta. Tech. Bul. (n.s.) 2, 38 pp., illus.

(Approximately 9 acres of forest range are needed to produce top gains for 500-pound steer from March to January.)

HARRISON, R. P.
Bark beetles and their control in Georgia. Ga. For. Res. Council Rpt. No. 2, 6 pp., illus.

(Identification, symptoms, prevention of attack, and control of the principal bark beetles of Georgia.)

HAWLEY, N. R.
Place of cattle grazing in a 50-year partnership in forest research. AT-FA Jour. 18(4): 12-13.

(Cattle in the George Walton Experimental Forest help maintain firebreaks and contribute to returns from the forest.)

HEPTING, G. H.
Diseases of the forest. Forest Farmer Manual, 4th ed., pp. 169-170.

(Research is increasing the knowledge of important forest diseases in the South, but more practicable control methods are needed for some of them.)

HEPTING, G. H.
Forest disease research in the south. Jour. Forestry 54(10): 656-660.

(Research effort and accomplishment in coping with important southern tree diseases.)

HOCKER, H. W., Jr.
Certain aspects of climate as related to the distribution of loblolly pine. Ecology 37(4): 824-834.

(Distribution is associated with average winter temperature and the frequency and intensity of both winter and summer rainfall.)

HOEKSTRA, P. E.
Pre-harvest loss of cones in slash pine. South. Lumberman 193(2417): 215-216. Dec. 15.

(Only 30 to 45 percent of slash pine flowers produced mature cones. As many as 45 percent of mature cones were defective.)

JOHNSON, E. A., and DILS, R. E.
Outline for compiling precipitation, runoff, and ground water data from small watersheds. Southeast. Forest Expt. Sta. Paper 68, 40 pp., illus.

(Systematic methods and forms for compiling basic hydrologic data.)

JOHNSON, E. A., and KOVNER, J. L.
Effect on streamflow of cutting a forest understory. Forest Sci. 2(2): 82-91, illus.

(Cutting dense understory of laurel and rhododendron, representing 22 percent of the total basal area on a 70-acre watershed, resulted in an annual increase of 2 inches in streamflow for the first 6 years and a corresponding decrease in evapotranspiration.)

KEETCH, J. J., and GLADSTONE, M. C.
1954 forest fires and fire danger in Connecticut, Kentucky, Maryland, Massachusetts, Pennsylvania, Rhode Island, and Vermont.

(Seven separate state reports containing tables and graphs analyzing forest fires and fire danger.)

KEETCH, J. J., and GLADSTONE, M. C.
1955 forest fires and fire danger in Connecticut, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.

(Thirteen separate state reports containing tables and graphs analyzing forest fires and fire danger.)

KOWAL, R. J.
Forest Insects. Forest Farmer Manual, 4th ed., p. 169.

(Progress in forest entomology in the South and its increasing importance in relation to forest practices in the future.)

KOWAL, R. J.
Progress and needs in forest insect research, survey, and control in the Southeast. (Abs.) Assoc. South. Agr. Workers Proc. p. 129.

(A review of forest insect research, surveys, and control in the Southeast.)

KREIS, E. A., Jr., BENNETT, F. A., and PATTERSON, A. E.
A site prediction test in slash pine plantations in the middle coastal plain of Georgia. Southeast. Forest Expt. Sta. Res. Note 93.

(Site quality estimated from depth to mottling by means of Barnes and Ralston method agreed closely with observed site quality in plantations in the middle coastal plain of Georgia, except on soils where depth to mottling was less than 10 inches.)

LANGDON, O. G.
Elevation and tree growth. South. Lumberman 193(2417): 191-192. Dec. 15.

(After 3 years the survival of South Florida slash pines planted on the ridges in abandoned fields was 3 times that of trees planted in the furrows, even though the difference in elevation was only 6 inches.)

LARSON, P. R.
Discontinuous growth rings in suppressed slash pine. Tropical Woods 104: 80-99.

(Discontinuous rings in suppressed slash pine trees from an even-aged stand were traced both circumferentially and vertically. "Islands" of ring discontinuity on the boles of suppressed trees may be due to localized deficiency of auxin because of limitations in bud development in the crown.)

LARSON, R. W.
Hardwood timber resources in Central and North Georgia. Southeast. Forest Expt. Sta. Paper 70, 48 pp., illus.

(Trends, makeup, and use of hardwoods.)

LOTTI, T.
Good seed production from a young stand of loblolly pine. Southeast. Forest Expt. Sta. Res. Note 97.

(A 10-year record of seed production in a partially cut, 35-year-old loblolly pine stand. Over 1 million sound seeds per acre were produced in 1955.)

LOTTI, T.
Eliminating understory hardwoods with summer prescribed fires in coastal plain loblolly pine stands. Jour. Forestry 54(3): 191-192.

(Four annual summer fires killed 90 percent of waxmyrtle stems and roots, 60 percent of sweetgum, 40 percent of blackgum, and 20 percent of the stems and roots of miscellaneous oaks.)

LOTTI, T.
Growing loblolly pine in the South Atlantic states. U. S. Dept. Agr. Farmers' Bul. 2097, 33 pp., illus.

(Directions for handling small tracts of loblolly pine as a paying crop from seed to final harvest in Virginia, North Carolina, South Carolina, and Georgia, and to a lesser extent elsewhere.)

LOTTI, T.
A half century of forest research. Forest Farmer XV(7): 12-13, 22.

(Research in South Carolina from 1905 to the present.)

McCORMACK, J. F.
Forest statistics for the mountain region of North Carolina. Southeast. Forest Expt. Sta. Forest Survey Release 46, 46 pp., illus.

(Statistics on forest area, timber volume, growth, and cut, with trends in forest area and timber volume.)

McCORMACK, J. F.
Forest statistics for the Piedmont of North Carolina, 1956. Southeast. Forest Expt. Sta. Forest Survey Release 48, 44 pp., illus.

(Statistics on forest area, timber volume, growth, and cut, with trends in forest areas and timber volume.)

McCORMACK, J. F.
18 million cords of pulpwood produced in southern states during 1955. Southeast. Forest Expt. Sta. Res. Note 91.

(Pine, hardwood, and chestnut volumes, by state.)

McMILLEN, J. M.
Seasoning hickory lumber and handle blanks. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. No. 4, 36 pp., illus.

(Describes proper air-drying and kiln-drying procedures for hickory lumber, handle stock, and other items.)

MEGINNIS, H. G.
Forestry and water resource development in the south. Forest Farmer XVI(2): 12-13, 28, 30-32.

(Some water supply needs and prospective regional developments, and how these may affect Southern forestry enterprises.)

MEGINNIS, H. G.
Principles of watershed management based on current research. Watershed Mgt. Pa., Interstate Com. Potomac River Basin, pp. 15-19.

(Review of accomplishments in watershed research and some principles and concepts developing out of it with particular reference to plant-soil-water relationships.)

MERKEL, E. P.
Bark beetle epidemics and rainfall deficiency in the Southeast. (Abs.) Assn. South. Agr. Workers Proc., p. 130.

(Bark beetle epidemics as related to periods of rainfall deficiency in the Southeast.)

MERKEL, E. P., and KOWAL, R. J.
Forest insect conditions in the Southeast during 1955. Southeast. Forest Expt. Sta. Paper 67, 9 pp.

(Discussion of survey and control activities.)

NELSON, R. M.
Weight loss by fuel moisture sticks from weathering. Southeast. Forest Expt. Sta. Res. Note 100.

(The present method of preweathering and 2-gram correction during exposure at fire danger stations in the South is for all practical purposes satisfactory.)

NELSON, T. C., and JACKSON, L. W. R.
Yellow poplar plantations. Forest Farmer XV(10): 11.

(Yellow-poplar planted 6 x 6 feet had 153 square feet of basal area and 30 cords per acre at 17 years. Survival differed with site in other plantations. Ground preparation, fertilization, and irrigation quadrupled height growth in the first year.)

ORR, L. W., and KOWAL, R. J.
Progress in forest entomology in the South. Jour. Forestry 54: 653-656.

(Progress in study of insects; also probable trends and needs of the future.)

PAGE, R. H.
[Untitled.] Forest Utilization Serv. Release No. 1, 2 pp.

(Purpose and type of work to be undertaken by Forest Utilization Service in Georgia, a cooperative effort between the Georgia Forestry Commission and the U. S. Forest Service.)

PAGE, R. H.
Air seasoning. Forest Utilization Serv. Release No. 2, 2 pp.

(A checklist covering principal factors in air drying.)

PAGE, R. H.
Wood moisture relations. Forest Utilization Serv. Release No. 3, 2 pp.

(Effect of moisture content on various physical and mechanical properties of wood.)

PAGE, R. H.
Paper overlays. Forest Utilization Serv. Release No. 5, 2 pp.

(A method of improving the quality or surface characteristics of low-grade lumber.)

PAGE, R. H.
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(Treating fence posts with water-borne preservatives.)

PAGE, R. H., and BOIS, P. J.
Particle board. Forest Utilization Serv. Release No. 4, 2 pp.

(Methods of manufacturing particle board from wood chips.)

PETER, R.
An inexpensive method for measuring charcoal kiln temperatures. Southeast. Forest Expt. Sta. Paper 73, 9 pp., illus.

(Method of calibrating an inexpensive standard brand D. C. microameter to measure charcoal kiln temperatures.)

POMEROY, K. B., and COOPER, R. W.
Growing slash pine. U. S. Dept. Agr. Farmers' Bul. 2103, 28 pp., illus.

(Information to owners of small wooded tracts for management, protection, and harvesting of slash pine throughout its range.)

RENSHAW, J. F.
Make more money from your white pine trees. Farmers Federation News 37(4): 16-17.

(Points out the benefits that can be expected from pruning 80 to 100 selected trees per acre in white pine stands.)

RENSHAW, J. F.
The Southern Appalachian Research Center. Southeast. Forest Expt. Sta., 38 pp., illus.

(A pocket-size illustrated booklet of research activities and projects.)

ROTH, E. R.
Decay following thinning of sprout oak clumps. Jour. Forestry 54(1): 26-30.

(Twenty-three percent of sprouts remaining in thinned clumps were later found to be decayed, and thinning wounds larger than 3 inches d.b.h. stayed open many years, exposing the remaining stem to decay.)

RUMMELL, R. S.
Range management research in south Florida, a project analysis. Southeast. Forest Expt. Sta. Paper 71, 48 pp., illus.

(Major range management problems in south Florida are evaluated and a research program proposed for their solution. Background material included.)

RUMMELL, R. S.
Trees and cattle on longleaf-slash pine lands. The Consultant 1(4): 2-8.

(Problems in using longleaf-slash pine lands for tree and cattle raising.)

SCHOPMEYER, C. S.
Naval stores orchards for future gum production. AT-FA Jour. 19(2): 12-13, 17. Also, with title Gum orchards for future naval stores production, Naval Stores Rev. 66(9): 8.

(Recommends establishment of gum orchards to fulfill an expected demand of 1 million drums of rosin annually by 1970.)

SHEPHERD, W. O., HUGHES, R. H., DILLARD, E. U., and REA, J. L.
Pasture firebreaks: construction and species trials on pond pine sites in North Carolina. North Carolina Agr. Expt. Sta. Bul. 398, 33 pp., illus.

(Pasture firebreaks proved most effective when established and managed as good improved pastures. Requirements include adequate seedbed preparation, ample fertilization, mowing, moderate grazing, and some use of palatable native herbage for supplemental feed.)

SHIPMAN, R. D.
Furrow old fields to plant longleaf in the sandhills. Southeast. Forest Expt. Sta. Res. Note 98.

(Survival was 92 percent for longleaf pine seedlings planted in furrows in old fields compared to 59 percent in unfurrowed fields.)

SMITH, R. H.
Controlling lyctus powder-post beetle infestations in wood by surface applications of certain oil preparations. Pest Control Mag. 24(4): 42, 45.

(Effectiveness of oil preparations and solvents applied as brush treatments in controlling lyctus infestations.)

SMITH, R. H.
Death of a pine. Forest Farmer XV(12): 7.

(Illustrates the deterioration rate of slash pine trees in north Florida attacked by the black turpentine beetle.)

SMITH, R. H.
The rearing of Lyctus planicollis and the preparation of wood for control tests. Jour. Econ. Ent. 49(1): 127-129.

(Method of rearing an adequate supply of beetles with a relatively small amount of work.)

SMITH, W. R.
Small sawmills--asset or liability. The Lumberman, pp. 104-106, illus. Jan.

(Small sawmills can be an asset if concentration yards and lumber buyers pay appropriate prices for graded lumber, thus providing an incentive to the sawmill operator to do a better job.)

SMITH, W. R.
Specialty products from hardwood and pine in the South. Jour. Forestry 54(10): 646-649.

(Describes varied wood products made from hardwood lumber.)

SMITH, W. R.
Technical training through short courses. Forest Prod. Jour. 6(1): 11A-12A.

(Short courses given in the past 5 years and short courses planned for the next 5 years by forestry schools and laboratories in the United States.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Southeastern Forest Insect and Disease Newsletter No. 1, 3 pp.

(Forest insect and disease conditions during the period January to April.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Southeastern Forest Insect and Disease Newsletter No. 2, 6 pp.

(Forest insect and disease conditions during the period April to September.)

SPEERS, C. F.
Pales weevil control with insecticides: first year results. Southeast. Forest Expt. Sta. Res. Note 96.

(Life history and control of pales weevil with insecticides. Comparative results from various methods of control.)

SPEERS, C. F.
Pales weevil controlled with sprays and dips. (Abs.) Assn. South. Agr. Workers Proc., pp. 129-130.

(Dipping and spraying pine seedlings with insecticides to prevent pales weevil damage.)

SPEERS, C. F.
Radioisotopes in forest insect studies. (Abs.) Assoc. South. Agr. Workers Proc., p. 130.

(Techniques of treating 100 white grubs and 20,000 southern pine beetles with radioisotopes to determine their movements.)

STOREY, T. G.
How to convert tower anemometer wind velocities to wind velocities used on the 8-100-0 meter. Southeast. Forest Expt. Sta. Res. Note 92.

(An improved table for converting wind velocities measured above the forest canopy to the 20-foot standard used with the 8-100-0 fire danger meter.)

TARAS, M. A.
Buying pulpwood by weight--as compared with volume measure. Southeast. Forest Expt. Sta. Paper 74, 11 pp., illus.

(A discussion of weight and volume measurement of pulpwood species in the Southeast.)

TODD, A. S., Jr.
Trends in the price of southeastern pulpwood. Southeast. Forest Expt. Sta. Res. Note 99.

(Shows average price of rough pine and hardwood pulpwood in the Southeast for years 1938 through 1956 for rail wood, truck wood, and the average for all wood.)

WAHLENBERG, W. G.
An early test of levels of growing stock in Appalachian hardwoods. Jour. Forestry 54(2): 106-114.

(Presents figures on stand development and diameter, volume, and value growth in relation to initial stocking in old-growth Appalachian hardwood stands in the Bent Creek Experimental Forest. Report based on fifty 1-acre plots.)

WAHLENBERG, W. G., and OSTROM, C. E.
Geographic variation in climate in the loblolly pine region. Southeast. Forest Expt. Sta. Res. Note 94.

(Summer rainfall is low in the western inland portion of the loblolly pine range and extremely high in the southeastern portion.)

WENGER, K. F.
Comments on "Some treatment effects on loblolly and shortleaf pine reproduction." Jour. Forestry 54(3): 194-195.

(Seed and seedbed requirements for natural regeneration of loblolly pine in northeastern North Carolina are shown to be essentially the same as in southeastern Arkansas.)

WENGER, K. F.
Growth of hardwoods after clear-cutting loblolly pine. Ecology 37(4): 735-742.

(Trends in height growth and in area occupancy of sprout clumps of important hardwood species in relation to season of logging and burning and gross soil characteristics in tracts where the loblolly pine overstory had been clear cut.)

WHEELER, P. R., and CRUIKSHANK, J. W.
The forest resources of the South. Jour. Forestry 54(10): 629-632

(Forest area, ownership, major forest types, forest conditions, total and sawtimber volume, growth, and timber cut.)

WITHEROW, B. M.
Information about the charcoal industry in the Southeast. Southeast. Forest Expt. Sta., 12 pp., illus.

(A compilation of information on charcoal manufacturing methods, yields, costs, and returns, and sources of information.)

WORRELL, A. C., and TODD, A. S., Jr.
Fence posts for Piedmont farms: a case study of requirements and supply in Jasper County, Georgia. Ga. Agr. Expt. Sta. Bul. (n.s.) 10, 35 pp., illus.

(Number and kind of fence posts used, their cost by kind of post, number of posts needed in the future, and possible sources of supply.)

ZAK, B.
Seed orchards. Forest Farmer XV(12): 8-9, 16-17.

(Factors to be considered in the establishment of seed orchards and the advantages to be gained from seed orchards.)

ZAK, B.
Experimental air-layering of shortleaf and loblolly pine. Southeast. Forest Expt. Sta. Paper 69, 12 pp., illus.

(Methods of air-layering stems and needle fascicles to obtain rooted cuttings.)

ADDENDUM

The following item was omitted from the Station's 1955 Bibliography:

WILLIAMS, R. E., CASSADY, J. T., HALLS, L. K., and WOOLFOLK, E. J.
Range resources of the South. Georgia Agr. Expt. Sta. Bul. (n.s.) 9, 31 pp., illus.

Agriculture--Asheville

April 1958

Annual Report 1957

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

Joseph F. Pechanec,
Director

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

DIVISIONS AND CENTERS

SOUTHEASTERN FOREST EXPERIMENT STATION

December 31, 1957

Research Divisions	Officer in Charge
Forest Economics	James F. McCormack
Watershed Management	H. Glenn Meginnis
Forest Fire	Karl W. McNasser
Forest Utilization	Walton R. Smith
Range Management	H. Glenn Meginnis
Forest Diseases	George H. Hepting
Forest Insects	R. Joseph Kowal
Forest Management	Walter M. Zillgitt
Station Management	George B. P. Mullin

Principal Field Centers	Officer in Charge
Athens-Macon Research Center, Athens, Ga.	William A. Campbell
Cordele Research Center, Cordele, Ga.	Norman R. Hawley
Coweeta Hydrologic Laboratory, Franklin, N. C.	Donald E. Whelan
Lake City Research Center, Lake City, Fla.	Thomas F. McLintock
Piedmont Research Center, Union, S. C.	Louis J. Metz
Santee Research Center, Charleston, S. C.	Thomas Lotti
Southern Appalachian Research Center, Asheville, N. C.	Robert A. Campbell
Tidewater Research Center, Franklin, Va.	George F. Gruschow
Macon Forest Fire Research Center, Macon, Ga.	Robert W. Cooper

Why?

The following pages, briefly presenting selected accomplishments in our research program during 1957, bear testimony to good progress. We are proud of what we have done--but we are not satisfied. Too often we have no answer to the question "Why did this result take place?"

Release of seed trees three years before harvest cutting results in a greatly increased seed crop. WHY? Pales weevils feed voraciously on pine seedlings planted right after cutting in one stand and will hardly touch seedlings in a cutover stand nearby. WHY? Hickory logs often pop open with huge checks soon after felling. WHY?

Is this desire to know why just a matter of idle curiosity? Indeed not! Only by learning more about nature's basic laws and principles can we more accurately predict events, reproduce results, and more efficiently develop new and better ways of conducting the forestry job.

In the South, where the progress of forestry is so rapid, our forest researchers have of necessity spent most of their effort developing solutions to current practical problems, with little time and energy left over for the why's and wherefore's. As a result, we are digging deeper into our declining storehouse of basic information and we are not replenishing it fast enough. We not only need to fill in from below with new fundamental facts but we need to increase our reservoir of basic knowledge.

We are suffering right now from a lack of knowledge of the dynamics of forest soils, with their multitudinous interactions of roots, insects, other animal life, fungi, bacteria, actinomycetes, particulate matter, colloids, solutes, and moisture. We are ignorant about many of the physiological processes involved in the flowering and fruiting of trees and other plants. Many of our insects and diseases behave in ways that we simply cannot explain. The oaks and sweetgums are dying alarmingly in many places from causes unknown. We need to know more about convection processes and upper air movements as they contribute to blowup fires.

If we foresters expect to produce the equivalent of a DDT, a penicillin, or an electronics development for our field--that is, open up totally new avenues to the solution of our problems--we will have to step up our basic research effort. This will require improved facilities for basic research and highly skilled men to do the work. Outstanding scientists capable of creative research must be given time and freedom to follow leads they think will be important.

Pursuing the WHY will pay big dividends in the future management of forest lands. A broader attack on the unknown, the more deeply hidden secrets of nature, is bound to lead to whole new approaches to our problems. This is particularly true in such fields as forest soils, physiology, pathology, entomology, hydrology, and forest fire research.

Joseph F. Pechanec

CONTENTS

Annual Report, 1957
Southeastern Forest Experiment Station

FOREST MANAGEMENT

Past and present programs have created a need for better information on plantation management--the effects of climate, soils, initial spacing, survival, and thinning on yields of pine plantations. The planned expansion of the planting program has created a growing need for research on flower, cone, and seed production, nursery management, direct seeding and planting techniques, site preparation, the adaptability of species to soils and sites, and the selection and production of superior strains of trees. Research on natural stands of both pine and hardwoods is pointed toward more effective methods of controlling quality by elimination of cull trees and low-value species, increasing both volume and quality growth by regulating stand density, identifying the conditions of soil or site that favor growth of some species over the growth of their associates, and finding more efficient methods of natural regeneration.

Artificial Regeneration

Few Southern states can keep up with the demand for tree seedlings despite the rapid expansion of the forest nurseries. Seedling production in 1957 was 40 times that of 10 years ago. As nursery capacity increases, the shortage of high quality seed will either limit seedling production or necessitate the use of seed of low or unknown genetic quality. In the slash pine belt, both seed production areas and seed orchards are being installed to aid the enlarged planting program.

<u>Stimulation of Flowering on Young Slash Pine</u>

In these areas and orchards, the potential seed crop would be larger if the number of female flowers formed each year could be increased. In the seed production areas and older seed orchards the problem is simply to increase the number of female flowers. In young slash pine seed orchards the trees must be induced to produce flowers and seed before the normal 10 to 20 years of age.

Some success with both problems was reported by the Lake City Research Center. Early flowering was stimulated by root pruning, stem injury, and fertilization during April 1954 in a 6-year-old slash pine plantation. The trees were 7 years old from seed, and had not flowered previously. Root pruning was done to a depth of 1 foot in a circle of 2-foot radius around the tree. Stem

injury included wire strangling and ½-inch-wide partial girdles. A 3-12-6 fertilizer was used at rates of 5, 10, and 15 pounds per tree. Flower counts in February 1955 showed that root pruning, stem injury, and application of 5 pounds of fertilizer significantly increased the number of trees that bore flowers (table 1). Increasing the amount of fertilizer had no statistically significant effect beyond that produced by the application of 5 pounds per tree.

Table 1.--Number of 7-year-old slash pine trees (out of 36) bearing female flowers, by treatment

Fertilizer	No stem injury		Strangled by wire		Partially girdled	
	Roots pruned	Not pruned	Roots pruned	Not pruned	Roots pruned	Not pruned
	- - - Number - - -					
None	0	0	0	0	1	0
5 lbs.	1	0	6	2	10	4
10 lbs.	0	0	5	4	10	7
15 lbs.	1	1	4	1	17	7

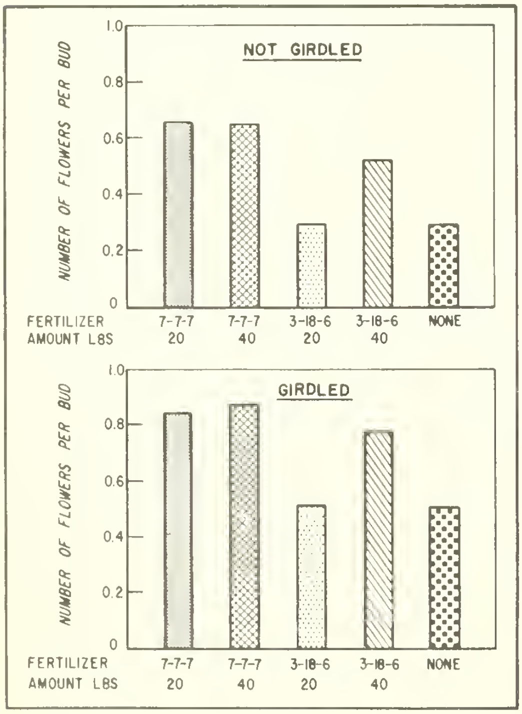

Figure 1.--Average number of female flowers per bud, following various treatments, on 21-year-old slash pine.

In a second study, partial girdling and 20 and 40 pounds per tree of 7-7-7 and 3-18-6 fertilizer were used on 21-year-old slash pine. The branches used for flower counts differed little in size, but showed great variety in number of buds, so the flower count was expressed as number of female flowers per bud. On these trees, partial girdling increased the number of flowers per bud (fig. 1). The 20 pounds per tree of a 7-7-7 fertilizer stimulated flowering but the same dosage of a 3-18-6 fertilizer did not. Doubling the dosage showed no additional effect with the 7-7-7 fertilizer but increased the flower crop with the 3-18-6 fertilizer. These encouraging but preliminary studies will be followed by other more intensive tests, and will be supplemented by efforts to control seed losses that occur between time of flowering and cone harvest.

Direct Seeding Slash Pine in South Florida

While the bulk of the pine seed collected goes to the nurseries, a portion of it is used for direct seeding. The first successful direct seeding on record in south Florida was made in November 1956 with repellent-treated slash pine seed. By July 1957 the catch averaged 810, 3,200, and 5,400 seedlings per acre for sowing rates of $\frac{1}{2}$, $1\frac{1}{2}$, and $2\frac{1}{2}$ pounds of seed per acre. These results are encouraging because in past direct seedings the untreated seed was usually eaten by birds and rodents.

The test area, in Collier County, Florida, is cutover pineland with the typical growth of saw-palmetto, gallberry, and wiregrass. Six-foot strips were chopped at 12-foot intervals with a Marden brushcutter in July 1956. Twenty-five pounds of slash pine seed were treated with 4 ounces of 50-percent wettable Endrin powder, 10.4 ounces of Arasan 75, 2.5 ounces of aluminum powder, and 1 quart of a 1:10 mixture of Dow Latex 512R and water. In November, four 1-acre plots were broadcast seeded at each of the three sowing rates.

On the basis of the July 1957 tally, chopping with the brushcutter had no significant effect on seedling establishment, and even the $\frac{1}{2}$ pound seeding rate produced an acceptable stand of seedlings (fig. 2). Since seedling mortality is likely to be high in this locality, however, a sowing rate of 1 to $1\frac{1}{2}$ pounds may be necessary to produce well-stocked stands of slash pine.

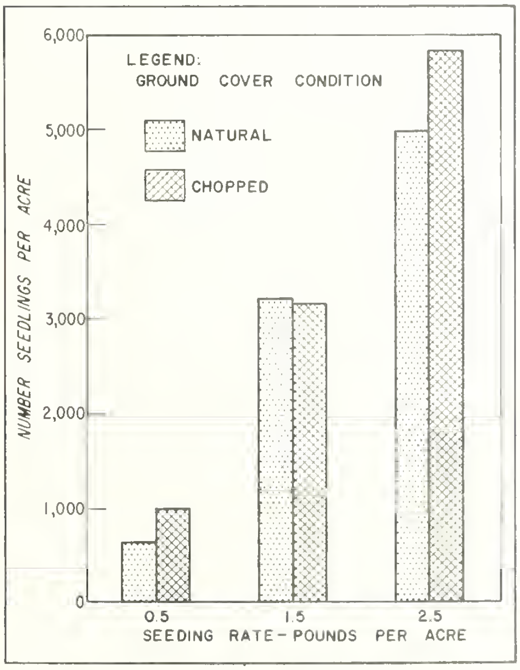

Figure 2.--Seeding rates had more effect on the number of slash pine seedlings established per acre than did ground-cover conditions.

These first successful results must be supplemented with other trials testing the direct seeding techniques on a range of soils, sites, climatic conditions, and ground covers before definite direct seeding recommendations can be made. In view of the short supply of seed, it seems likely that planting seedlings will continue to be the mainstay of the planting program for some time to come.

It is essential, also, that the supply of seed available for the planting program be stretched by making the fullest possible use of the seedlings produced in the forest nurseries. One solution is to increase the average quality of the seedlings by better nursery management--through fertilization, irrigation, pest control, and by controlling seedbed density. Another solution is to develop planting techniques and prescriptions to make full use of the planting stock now available.

Deep Planting Seems Best for Slash Pine

Developing better planting techniques has been an important part of the Station's work in the Georgia-Carolina Sandhills, where survival of conventionally planted trees, especially the smallest seedlings, may be poor. Even small slash pine seedlings can be successfully planted on the difficult sites of the South Carolina Sandhills if they are planted deep (fig. 3). Test plantations on three soil types (deep sand, loamy sand, and sandy loam) show that first-year survival and growth improved with depth of planting for both grade 2 and grade 3 planting stock. As table 2 shows, small trees are helped the most, especially the smallest seedlings with poor root systems, whose survival was doubled by planting to the bud. Deep planting does not eliminate the growth differential between grade 2 and grade 3 stock, but it can mean the difference between success and failure when it is necessary to plant grade 3 stock.

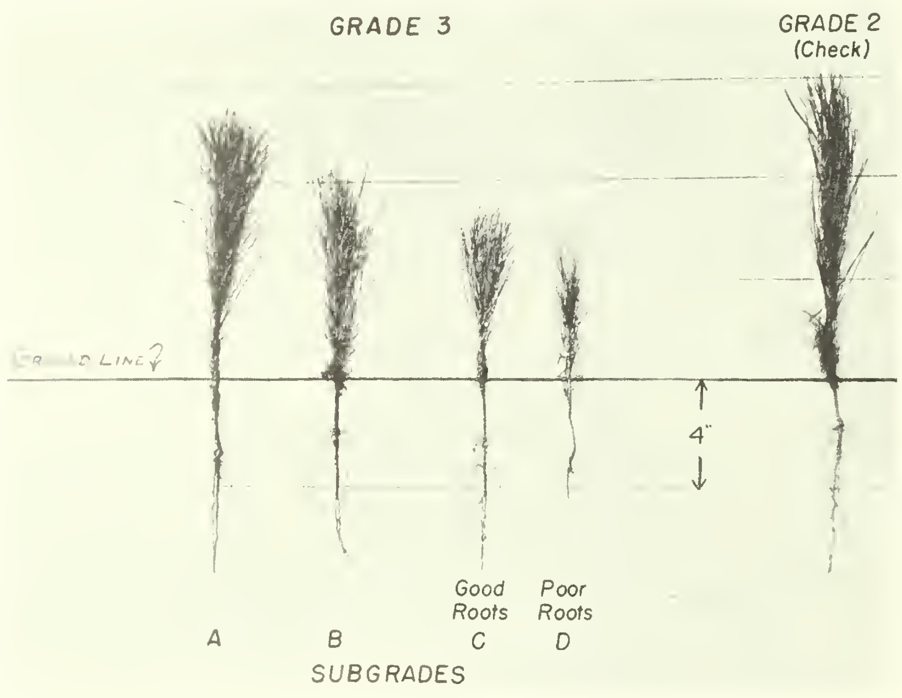

Figure 3.--Grades and subgrades of slash pine seedlings tested in depth-of-planting experiment. A, B, C, and D are subgrades of Grade 3 stock.

A Species Comparison on Flatwoods Soil

Along with the direct seeding trials and tests of planting techniques, species adaptability tests are being made. These match the species available for planting with the soils and sites that need to be planted. The big planting programs in the flatwoods of northern Florida and southeastern Georgia favor slash pine almost exclusively for both cutover tracts as well as for old fields. At the same time, natural regeneration in the flatwoods consists almost entirely of slash pine. It is the predominant species on poorly drained sites, and is reseeding aggressively on the higher elevations at the expense of longleaf pine.

Table 2.--First-year survival and growth of slash pine seedlings by grade and planting depth

Seedling grade	Standard depth		Half-stem depth		To-bud depth	
	Survival	Height growth	Survival	Height growth	Survival	Height growth
	Percent	Inches	Percent	Inches	Percent	Inches
Grade 2	82	4.9	92	5.7	98	8.9
Grade 3						
Subgrade A	60	3.5	80	3.8	95	5.5
Subgrade B	70	3.2	80	3.4	93	4.8
Subgrade C	81	3.3	87	3.7	95	5.4
Subgrade D	43	2.5	64	2.6	89	3.8
All grades	67	3.5	81	3.8	94	5.7

This continued planting and natural regeneration of slash pine will tend, in time, to establish a pure slash pine forest in all the flatwoods of northern Florida and southeastern Georgia except the ponds. A certain danger is inherent in such a trend: pure forests may be more vulnerable to disease and insect epidemics than are mixed forests.

With this in mind, researchers made a trial planting of slash, loblolly, Sonderegger, and longleaf on Leon fine sandy soil near Lake City, Florida. Leon fine sand is one of the poorer soils in the flatwoods area, especially if underlain by a hardpan, as was the site in this study. The planting site had been completely cleared 6 years before, the longleaf stumps removed, and the area disked. At the time of planting, the area was covered with broomsedge, but no palmetto was present.

Survival of longleaf pine was surprisingly good, with 83 percent survival despite three dry growing seasons after planting (table 3). Slash pine, with 75 percent survival, was second and Sonderegger and loblolly pine were much less successful, with 59 and 58 percent survival. Height growth after 3 years shows an entirely different ranking. Loblolly grew best, followed by slash and then Sonderegger. Longleaf, as expected, remained behind at the end of only 3 years. Loblolly pine was the only species damaged by tip moth.

Table 3.--Survival, average height growth, and average total height after 3 growing seasons

Species	Survival	Height growth	Total height
	Percent	Feet	Feet
Slash	75	2.8	3.3
Loblolly	58	3.2	3.5
Sonderegger	59	1.7	1.9
Longleaf	83	0.7	0.8

While it is too early to draw final conclusions from this study, some definite statements can be made. Sonderegger is not suited to replace slash pine for planting on Leon fine sand. Loblolly pine is by no means ruled out; improved techniques may increase its survival

Figure 4.--A seed trap installed in a mixed oak stand in the Piedmont. The wire netting reduces acorn losses from deflection and keeps out rodents.

and tip moth damage may actually detract little from the timber value at harvest time. Longleaf pine, with a much better performance than expected, shows promise for the future and justifies continuing research. Slash pine still seems to be the best choice for planting under the conditions of this study, although its advantages are not so great as has been assumed.

Planting Hardwoods

Although both the current planting program and research in artificial regeneration are heavily slanted toward the southern pines, increasing attention is being directed to the better hardwood species in the Coastal Plain and the Piedmont as well as in the mountains. Seed production studies are under way at several centers (fig.4). Both direct seeding techniques and planting of seedlings and cuttings are being tested in the bottomland hardwood sites of the Coastal Plain and Piedmont (figures 5, 6, and 7).

Figure 5.--Growth of direct seeded cherrybark oak in the fourth growing season after sowing. This is one of a series of plots on the Santee Experimental Forest testing the seeding and planting of hardwoods on bottomland sites in the Coastal Plain.

Figure 6.--Cottonwood plantations in central Georgia bottomlands survive and grow well. Heights of 15 to 20 feet in 3 years are not unusual. An odd finding is that the trees may need wire screens or repellents as protection against beaver. Inset shows a beaver-felled sapling.

Figure 7.--Yellow-poplar seedlings graded by stem diameter at the root collar in 1/20-inch units and by root development. Seedlings less than 5/20-inch in diameter are poor planting risks and should be culled.

Since bottomland sites are flooded periodically, the effects of flooding on survival and growth of hardwoods are under test at the Athens-Macon Research Center. In this study, tanks are used to control the period of inundation (fig. 8). Tanks with about 20 yellow-poplar seedlings per tank were flooded in January and May, and the seedlings completely covered with water for periods of 1, 2, 3, 4, 7, and 14 days. The dormant-season flooding had no effect on survival and growth. In the May series, the survivals were 100, 100, 90, 50, 30, and 5 percent. The adverse effect on growth began with 3 days of flooding and increased sharply as the period of flooding increased. The tanks flooded in January were reflooded in June, when the seedlings had grown about 1 foot above the surface of the tanks. The results were similar to those of the May series in which the seedlings were completely covered by water.

These flooding tests will be continued with other species which will be subjected to the same procedure used for yellow-poplar.

Figure 8.--Flooding yellow-poplar seedlings for 3 days and longer during the growing season sharply reduced both growth and survival.

Natural Regeneration

The recent emphasis on research in artificial regeneration tends to overshadow the equally important work on natural regeneration. Over most of the Southeast, the area planted to pine each year is still less than the area of pineland being lost to hardwoods and brush after cutting. This trend will continue until more is known about the effects of stand and climatic conditions on seed production, the seedbed requirements and seeding habits of the desired species, and methods of controlling competing vegetation.

All too often the failure to get adequate natural regeneration can be traced to lack of seed.

Seed Production of Shortleaf Pine in the Piedmont

Observations being made in eight stands in the Carolinas and Georgia show that shortleaf pine produces large amounts of seed in some years and only negligible amounts in others (table 4).

Table 4.--Sound seed per acre produced by eight shortleaf pine stands in the Piedmont

Location of stands	1954	1955	1956
		Number	
Morganton, N. C.	46,000	185,600	2,000
Morganton, N. C.	48,000	181,600	5,200
Clemson, S. C.	7,200	228,400	1,200
Clemson, S. C.	1,200	63,200	400
Athens, Ga.	33,200	154,400	0
Athens, Ga.	20,000	103,600	0
Union, S. C.	3,200	31,600	1,200
Union, S. C.	500	22,600	0

The seed crop was small in 1954 and large in 1955. In 1956 the crop was a failure, apparently because a frost in March 1955 destroyed most of the flowers. These seed-crop records must be continued over a period of years before anything can be said about the effects of geographic location, stand characteristics, and annual weather variations on seed production. A similar seed production study in loblolly pine stands in northeastern North Carolina has yielded useable information, also.

Annual Variation in the Seed Crops of Loblolly Pine

Seed-trapping records in the Bigwoods Experimental Forest in three mature, undisturbed stands of loblolly pine show that the current year's seed crop varied with two important factors. These were the May-to-July rainfall 2 years earlier and its interaction with the seed crop that also occurred 2 years earlier. As shown in figure 9, a heavy crop in one year apparently makes a poor crop 2 years later virtually certain because only an excessive amount of rainfall will increase the prospective crop to the average level. Since a heavy crop can be predicted a year in advance by the cone-ratio method, a poor crop can be detected 3 years before it matures. If the released seed trees needed were selected and treated during the winter following this first indication, their increased seed production would be available in the year of the poor crop.

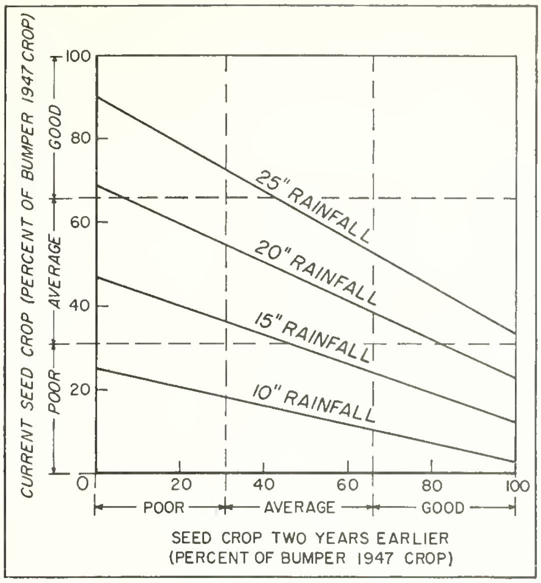

Figure 9.--The size of the current seed crop varies with the interaction of the May-to-July rainfall 2 years earlier and the seed crop that also occurred 2 years earlier.

When, on the other hand, the inspection a year in advance shows a poor crop on the trees, the crop 3 years later cannot be predicted with the same confidence because in that case rainfall has a much greater effect (fig. 9). However, the prospective crop is likely to be at least average, since only seriously deficient rainfall during the critical period will reduce it to the poor level.

These results suggest that the response in seed production of loblolly pine trees to crown release may be due to increased soil moisture rather than to increased light. If this relation proves reliable, it can be used in seed-crop forecasting, and in planning cone collections and regeneration measures.

Stand Improvement

The continuing demand for high quality pine and hardwood timber and the limited market for the poorer hardwoods are responsible for the increasing use of stand improvement measures in the South. On soils and sites best suited to pine, such measures will include improvement cuts in young stands, pruning, and the use of prescribed fire, chemicals, and mechanical methods to eliminate or minimize competition from hardwoods and brush. In hardwood stands, where desirability is a question of quality differences rather than species differences, the single-tree treatments--cutting or girdling, with and without chemicals, and basal sprays--are used to favor the better trees.

Pruning is usually restricted to young even-aged stands, since the dominants in an all-aged stand are usually too large to prune, and the suppressed and intermediate trees are usually too slow-growing to make pruning worth while. In pruning hardwoods, a further disadvantage is that nondominant trees tend to develop many epicormic branches following pruning and release. The Station has successfully pruned a young even-aged stand of sycamore, but most of the work has been in young pine stands. To date the conventional techniques of cutting flush wounds with pruning saws have been most successful.

Loblolly Pine Not Suited for Bud Pruning

Bud pruning was tested in a 5-year-old loblolly pine stand on the Hitchiti Experimental Forest near Macon, Georgia. Portions of the stand, both pruned and unpruned, were also thinned from an average spacing of 6x6 feet to 12x12 feet. The marked reduction in height and diameter growth of the pruned trees in both the thinned and the unthinned stands is serious enough in itself to make bud pruning impractical (table 5).

Table 5.--Growth after 4 successive years of treatment

Treatment	Trees	Relative diameter growth	Relative height growth
	Number	Percent	
Pruned and thinned	75	51	53
Pruned only	75	34	69
Thinned only	75	132	95
Control	75	100	100

In addition to the growth loss, bud pruning has other disadvantages: epicormic branches form along the pruned portions of the stem (fig. 10), the basal branches on some trees become as large as the main stem (fig. 11), and the incidence of Nantucket pine moth damage to the terminal buds is increased. All three of these disadvantages are greatest in the stands that are both pruned and thinned. Conventional pruning techniques not only avoid these disadvantages but also defer pruning until the crop trees can be selected with greater certainty.

Figure 10.--One season's growth of epicormic branches on pruned portion of main stem of loblolly pine.

Figure 11.--Basal branches left on this bud-pruned tree, even though cut back once, are again as large as the main stem.

Killing Cull Hardwoods in the Coastal Plain

Prescribed summer fire has proven to be an effective and inexpensive technique for controlling lowland hardwood and shrub understories on loblolly pine sites in the Coastal Plain. Fire alone will not kill the larger hardwoods, nor can it be used in the lowland hardwood stands, where desirability is a question of tree quality rather than species. In these stands the more expensive but highly selective single-tree treatments must be used.

Axe or machine girdles alone are fairly effective in top-killing many hardwoods, especially the sawtimber-size culls. When the goal is a low-cost technique that will prevent sprouting and completely kill the trees, chemical treatments may be the answer.

A mixture of 2, 4, 5-T and oil was successful in a 1000-tree test on the Santee Experimental Forest, near Charleston, S. C. The mixture was 1 part 2, 4, 5-T (4 lbs. acid, propylene glycol butyl ether ester) to 20 parts of fuel oil. Application was in late May and early June in frill girdles made at a convenient chopping height.

The trees were residual culls from a harvest cutting, ranging from 6 to 30 inches d.b.h., but averaging only 9 inches. All were located on a terrace of a typical Coastal Plain tributary stream in the swamp chestnut oak-cherrybark oak type. A survival count was made in late July, 14 months after treatment. Any tree with live foliage, living stem tissue, or sprouts was counted as living.

The treatment was 100-percent effective for swamp chestnut oak, post oak, cherrybark oak, Shumard oak, water oak, willow oak, bitternut hickory, white ash, and winged elm of all diameters and for sawtimber-size American hornbeam and sweetgum. The kill was 99 percent for small hornbeams, and 94 percent for small sweetgums. For American beech the kill was 91 percent for trees 6 to 10 inches d.b.h. and 73 percent for larger sizes. Only American holly showed substantial resistance to control: 67 percent of small trees killed, but only 33 percent of large trees dead after 14 months.

Costs were low, the entire job requiring only 37 man-hours of labor, 1-1/4 gallons of 2, 4, 5-T and 23-3/4 gallons of fuel oil. This was roughly equivalent to a cost of $50 to treat 13 acres averaging 77 cull trees totaling 34 square feet of basal area per acre.

The Station's silvical research covers a wide range of studies, some with immediate practical application and others that provide the basic findings for future work. Silvical research ranges from the development and testing of site indices through the identification and measurement of the effects of soil and site properties on tree growth to the interrelation of site and climate with growth and wood quality and the effect of growth substances on tree development. A good portion of the available silvical information from the experiment stations, schools, and other agencies has been compiled and will be published by the U. S. Forest Service in a manual of silvics for the important forest trees of the United States. Many of the individual species reports are being issued by the forest experiment stations. This Station issued reports in 1957 for slash pine, sand pine, scarlet oak, cherrybark oak, and flowering dogwood. Other reports are being prepared and will be issued in 1958. Reviews of past work made in the course of these writeups showed a need for continued silvical research to fill the many existing gaps.

Site Indices for Natural Slash Pine

Until recently the only published 50-year site indices for slash pine were those in U. S. Department of Agriculture Miscellaneous Publication 50, "Volume, Yield, and Stand Tables for Second-Growth Southern Pines." The applicability of these site indices to the flatwoods slash pine type of northeast Florida and southeast Georgia has now been tested by the Lake City Research Center. Age and height measurements were taken in natural stands containing dominant 40- to 60-year-old slash pines and younger trees in the 15- to 40-year age class. Both age classes were on identical sites, but were separated far enough to allow each to make free growth.

The site estimates from the younger trees were adjusted by the use of site estimates from the older trees as a standard in an analysis similar to the one used by Coile and Schumacher[1/] for loblolly and shortleaf pines. The correction factor was applied to the site index curves in Miscellaneous Publication 50. The differences between the two curves were small, indicating that the old curves may overestimate site index values by only 1 to 2 feet for 15- to 30-year-old slash pine (fig. 12).

Good site indices have immediate practical use in timber management and also provide a basis for measuring the effects of soil and site properties in more basic studies of site quality. Soil-site indices and yield tables are being prepared for plantation-grown slash pine in the Carolina-Georgia sandhills and in the upper Coastal Plain of Georgia. In the Piedmont, soil-site studies are being made for some of the important hardwoods. Soil-site indices have already been issued for scarlet and black oak in the mountains.

1/ Coile, T. A., and F. X. Schumacher. Site index of young stands of loblolly and shortleaf pines in the Piedmont Plateau region. Jour. Forestry 51: 432-435. 1953.

Soil, Topography, and the Site Index for Scarlet and Black Oak

Site index and 20 properties of the soil and topography were examined on the Bent Creek Experimental Forest in the Southern Appalachians near Asheville, North Carolina, to correlate the soil and topography with site index of scarlet and black oak. It was found that only 3 of the 20 properties studied were of significant value in estimating site index. These three were depth of A horizon in inches, position on the slope, and percent of sand in the A horizon.

Because of the minor contribution of position on slope to the equation, the site indices can be shown in a simple 2-way table for middle-slope positions with 2-foot corrections for upper and lower slopes (table 6).

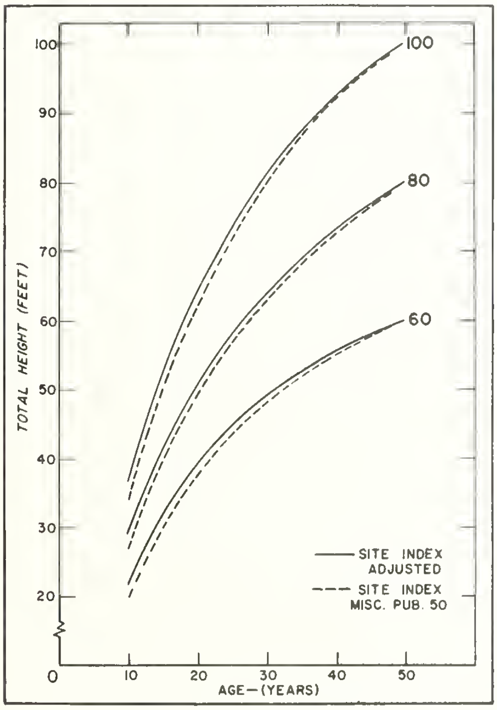

Figure 12.--Relation between adjusted curves and those shown in Miscellaneous Publication 50, for site index of slash pine.

Table 6.--Site index of scarlet and black oak by percent of sand and depth of A horizon for middle-slope positions [1]

Depth of A horizon (Inches)	Percent of sand [2] in A horizon: 80	70	60	50
3	26	30	35	40
3½	30	35	39	44
4	35	39	44	49
4½	39	44	48	53
5	43	48	53	57
5½	48	52	57	62
6	52	57	61	66
6½	57	61	66	71
7	61	66	70	75
7½	65	70	75	79
8	70	74	79	84
8½	74	79	84	88
9	79	83	88	93
9½	83	88	92	97
10	87	92	97	101

1/ For lower slopes, add 2 feet to site index values; for upper slopes, subtract 2 feet from site index values.

2/ Percent of sand by the International Size Classification (0.02 to 2.0 mm.).

Percentage of Summerwood and Specific Gravity in Slash Pine

In addition to the effects of soil and site on growth and wood quality, the factors of climate must be taken into account. Wood density and percentage of summerwood are important to the wood-using industries; the strength of lumber, the yield of pulpwood, and the fiber characteristics of the pulp are largely determined by the two properties. They are in turn controlled by the relationship of environment and inheritance, combining to form the

complex pattern of growth. It is entirely possible that expressions of these factors of growth can be separated and quantitatively defined. Wood of the desired quality could then be grown by modifying the controllable factors by either silvicultural practices or genetic improvement.

Important findings along these lines were reported by Philip R. Larson in the "Effect of Environment on the Percentage of Summerwood and Specific Gravity of Slash Pine," Yale University School of Forestry Bulletin No. 63. This was a cooperative study; the field work done while Larson was at the Station's Lake City Research Center and the analysis completed and report written at the Yale University School of Forestry. The work at Yale was made possible by fellowship aid from the St. Regis Paper Company, the West Virginia Pulp and Paper Company, and the John A. Hartford Foundation Program in Forest Biology. The aim of the study was to evaluate the influence of growth rate and of age as well as the effects of geographic location and factors of environment on the specific gravity and percentage of summerwood in slash pine.

Larson found that within the range of ring width normally encountered, rate of growth exerted a negligible influence on both specific gravity and percentage of summerwood. The percentage of summerwood was the best single criterion for estimating specific gravity, and the effect of age predominated in controlling the percentage of summerwood gradient on the cross-section. On a plot basis, summerwood percentage increased from north to south and from west to east within the slash pine range. The only variables that could account for this variation were those related to moisture-holding capacity of the soil. After adjustment for rate of growth, good sites with high moisture-holding capacity showed the lowest percentage of summerwood. The best over-all expression accounting for the variation between plots was a multiple variable: percentage of summerwood increased with increasing June + July rainfall and with depth to a fine textured horizon. June + July rainfall was the best single variable accounting for the differences in percentage of summerwood between plots.

Inasmuch as neither summer rainfall nor depth to a fine textured horizon are controllable at a given location, improvement of wood density or pulping characteristics for slash pine apparently must come through genetic improvement rather than through silvicultural practices.

Drought, Mortality, and Diameter Growth

Variation in rainfall from year to year as well as from place to place can have a marked effect on tree growth. The 10-week drought from August 19 to October 29, 1954, gave the forests of middle Georgia a severe setback. The average mortality loss of merchantable-sized loblolly and shortleaf pine on the Hitchiti Experimental Forest was equivalent to half the normal growth in basal area. Loss of merchantable and smaller trees was most severe on shallow soils having less than 16 inches of effective depth above an impervious layer of parent material.

Increment cores taken from surviving trees show the distinct influence of rainfall on the amount and pattern of diameter growth (fig. 13). Total rainfall was 64 inches in 1953, 26 inches in 1954, and 44 inches in 1955. In 1954 the average diameter growth was only half that in 1953, but in 1955 diameter growth was back up to 80 percent of the 1953 growth. Most of the growth loss in 1954 was in summerwood. Apparently the heavy winter rainfall of 1953 helped maintain springwood growth in 1954, and the deficiency from 1954 reduced springwood growth in 1955. The latter was a year of normal rainfall, and normal growth was attained during the time of summerwood formation.

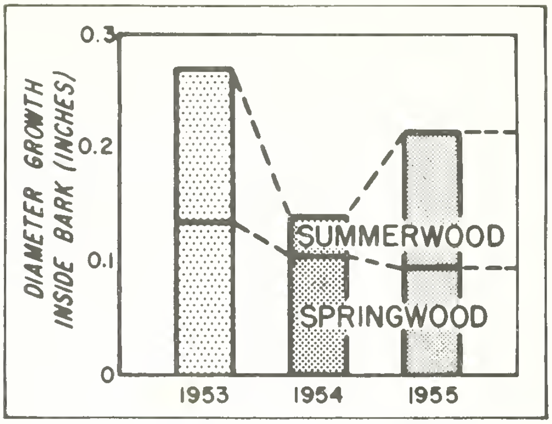

Figure 13. --Diameter growth of loblolly pine in the Georgia Piedmont before, during, and after the 1954 drought.

Gibberellic Acid Can Increase Height Growth

Silvical research includes the study of growth substances as well as the study of environmental factors. Recently, seedlings or cuttings of 11 southern tree species were used in a test of gibberellic acid treatment at the Athens-Macon Research Center. The potted trees were brought into a greenhouse in December, and as the trees broke dormancy a 1-percent solution of gibberellic acid was applied to the new shoot growth of every other tree of each species.

Eastern cottonwood showed very consistent increases in height growth, a number of plants growing over 30 inches during a $2\frac{1}{2}$-month period of observation. American sycamore showed even greater response, with an increase of 353 percent over the untreated seedlings (fig. 14). Yellow-poplar (fig. 14) and sweetgum showed increasing response throughout a 35-day period of observation. Cherrybark oak, willow oak, and southern red oak showed the most pronounced response immediately following the first flush of growth; as the second flush of growth began, the differences due to treatment diminished. White oak and eastern white pine had less clear-cut increases in height growth. Water oak showed no consistent response to treatment and Arizona cypress was damaged by treatment; the treated trees grew less in height than the untreated trees.

The practical use of gibberellic acid even for those species responding to treatment cannot be properly assessed from this preliminary study. It does, however, indicate the wide differences in response that apparently exist between species.

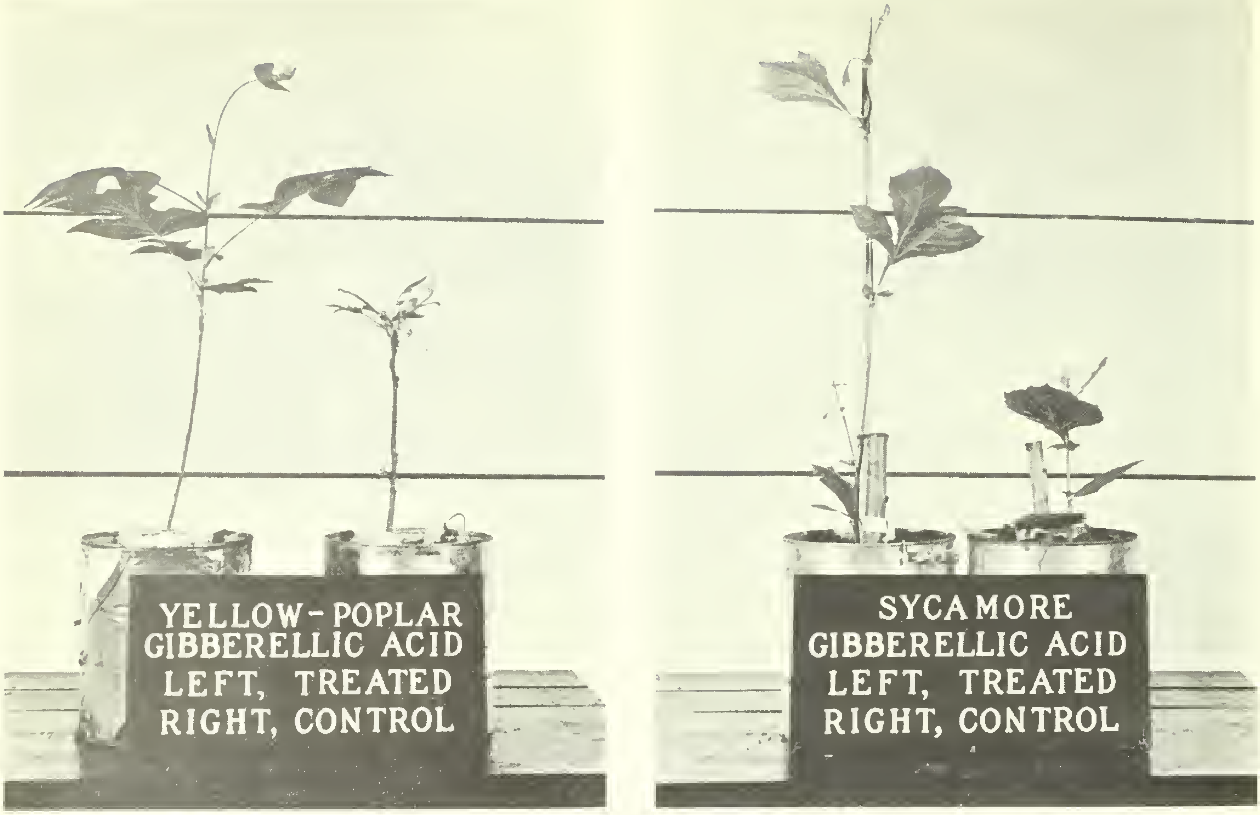

Figure 14.--Comparison of stems treated with 1-percent gibberellic acid in lanolin and checks of yellow-poplar and sycamore. Horizontal black lines are 12 inches apart.

Farm Woodland Management

Farm woodland management research is especially important in the Southeast because so much of the forest land in this region is owned by farmers and other small landowners. In most respects the silvicultural techniques applicable to public forests and large industrial holdings are also applicable to the farm woodland. The real differences are in the economics of management. The public forests ordinarily sell stumpage, while wood from industrial forests usually does not appear in the marketplace until after it has gone through the manufacturing plant. A farmer may sell stumpage, use his own timber on the farm, or he may produce rough forest products such as logs, pulpwood, poles, or fence posts. When he produces rough products, he is interested not only in the dollar return from the stumpage but also in the return from his labor and from the use of his own equipment.

Ten Years of Farm Woodland Management in the Southern Appalachians

Farm woodlands account for about 40 percent of the total woodland area of the Southern Appalachians. With proper care they could supply an important part of the forest products needs of the region and at the same time provide a sizeable supplement to the farm cash income. Few farm woodlands are now operating at top capacity in either respect.

In 1945, four areas on the Bent Creek Experimental Forest, near Asheville, North Carolina, were set aside to determine the returns possible from planned woodland management. These areas are representative of many farm woodlots in acreage as well as in stand characteristics. Cutting during the past 10 years has gradually removed species of low value and poor trees of all species. All cutting was done with such labor and equipment as a farmer would have available. The volume and value of the products removed are shown in table 7.

Table 7.--Volume and value of forest products harvested from the four areas, on a per-acre basis, 1946-1955

Period	Timber products				Other		Value of all products		
	Saw-logs	Fuel and pulpwood	Posts	Total	Xmas trees	Tan-bark	On stump	At roadside	F.o.b. market
	Bd.-ft.	Cords	Number	Cu.ft.[1]	Number	Tons	- - -	Dollars	- - -
1946-1950	1,120	1.82	3.0	377	--	0.1	14.00	40.00	59.00
1951-1955	1,150	2.87	1.1	473	0.2	--	21.00	57.00	84.00
Total	2,270	4.69	4.1	850	.2	.1	35.00	97.00	143.00
Yearly average	230	.47	.4	85	--	--	3.55	9.69	14.34

1/ Based on 85 cubic feet per cord and 5 board-feet per cubic foot, 1 cubic foot per post.

The higher value of timber cut during the second 5 years is largely a result of a general rise in stumpage values, but it also reflects the higher proportion of good logs now available following the early stand improvement cuts. Although the woodlands now contain less volume than they did 10 years ago, the total value of the standing timber is about the same. As this better quality growing stock continues to add volume and value through growth, the returns in the future will increase.

This 10-year summary shows that a farmer with such a woodlot would have received $3.55 per acre per year from the sale of stumpage. If he had done the woods work, his income would have been $9.69. If he had a truck and could load and haul his timber to market, his gross income would have been $14.34. These returns are not all clear profit; to reap the additional benefits the farmer must invest his own labor and use his own equipment. His net returns will vary with the value of timber cut and his skill and ability to do the woods work.

Tree Improvement and Genetics

The Southeastern Station, in cooperation with other forestry agencies in the South, has continued to expand its research in selecting, propagating, breeding, and testing genetically superior trees. As before, the development of superior strains of naval stores pines is carried on at the Lake City Research Center in Florida, and genetics work on all the southern pines and some work on hardwoods is largely done at the Athens-Macon Research Center in Georgia (fig. 15). These two centers do the bulk of the Station's tree improvement work, but all centers conduct field tests of selected strains and are active in the search for outstanding individual trees. Recent studies in genetics have been concerned with the inherited variations in resistance to disease and in physiological processes as well as in growth, form, and wood quality.

Figure 15.--As part of the tree improvement program in hardwoods, tree breeders are selecting individuals of outstanding form and vigor--also trees with figured grain. This unusual 20-inch poplar was found in Georgia. Bark formations indicate figured grain. Samples will be made into veneer to determine quality. Tree breeders will propagate this tree by grafts or cuttings and will cross it with similar specimens in an attempt to get a true-breeding strain.

Rust Resistance in Slash Pine

Southern fusiforme rust caused by Cronartium fusiforme is one of the most serious diseases attacking slash pine (fig. 16). The nature of this disease is well known, but little in the way of practical control measures is available for planted or natural stands.

Figure 16.--In this 12-year-old slash pine plantation, near Cordele, Georgia, nearly half the trees are infected with fusiform rust. About 12 percent of the trees are dead now, and the losses will increase.

One approach to the problem is to select or to develop resistant strains through planned breeding. A first step in this approach is to determine whether disease-free trees in infected stands produce seedlings having more than average resistance to the rust. Early results of 1-parent progeny tests at the tree improvement project at the Ida Cason Callaway Foundation, near Chipley, Georgia, show that some degree of rust resistance is passed on to the progeny (table 8). Seedling lots designated "control seed number 1 and 2" and "Southern Mississippi" were grown in the Foundation's nursery. Seed of control number 1 was purchased; seed of control number 2 and of Southern Mississippi were supplied by the Southern Forest Experiment Station. The "control seedlings" were purchased from a local nursery. The rest of the seed was from rust-free mother trees in a badly diseased plantation.

Although the results reported here are from few tests of short duration, they indicate that there are some inherent differences in susceptibility to rust among individual slash pine trees. More complete information will soon be available from periodic observations of these trees as they grow older and of trees in additional plantings made in 1954, 1955, and 1956 with seed from open and controlled pollinations.

Table 8.--Rust infection evident in the fall of 1955 in slash pine progeny from open pollination of unselected mother trees and disease-free mother trees

PROGENY FROM UNSELECTED MOTHER TREES

Origin	Planted spring 1952				Planted spring 1953			
	Seedlings	Stem cankered	Branch cankered	Total seedlings with canker	Seedlings	Stem cankered	Branch cankered	Total seedlings with canker
	Number	Percent	Percent	Percent	Number	Percent	Percent	Percent
Control seed 1	114	37	55	64	66	18	15	30
"Control seedlings"	104	28	58	64	42	29	33	48
Control seed 2	30	53	70	77	85	36	28	51
So. Mississippi	56	52	71	77	92	50	26	58
Average	--	42	64	70	--	33	26	47

PROGENY FROM DISEASE-FREE MOTHER TREES

Parent								
C-4	62	23	45	45	80	26	19	32
C-6	71	24	34	48	79	25	16	33
C-7	71	30	42	54	71	30	15	39
C-10	250	24	51	59	97	23	24	39
C-37	216	14	26	30	84	8	12	20
C-50	212	34	52	61	94	29	31	50
C-51	203	22	51	58	89	19	15	27
C-63	58	16	26	29	92	23	28	39
C-65	252	13	36	43	85	12	11	21
Average	--	22	40	47	--	22	19	33

Effect of Seed Source and Photoperiod on Photosynthesis, Respiration, and Growth of Loblolly Pine Seedlings

Loblolly pine seedlings from Florida and north Georgia were grown under long and short days for two months, and the CO_2 exchanges in photosynthesis and respiration were then measured to determine whether there were racial differences in photosynthetic activity and whether varying the day length would alter the basic rates of photosynthesis. This cooperative study with Duke University is a part of a broader study of factors affecting the range of species.

The larger Georgia seedlings, on a per-seedling basis, carried on photosynthesis at a faster rate than the Florida seedlings, and the rate of photosynthesis of long-day seedlings was higher than that of short-day seedlings. In actual growth the two sources were about equal, but as a percentage of initial height, the Florida seedlings outgrew the Georgia seedlings. The long-day seedlings outgrew the short-day seedlings in both cases. The long-day treatment was particularly effective for the Florida seedlings.

Further analyses suggest that the differences in rates of photosynthesis and respiration between sources and between photoperiods may be accounted for by differences in total length of needle (photosynthetic tissue) and not by differences in photosynthetic efficiency. The effect of long photoperiod is to produce a greater photosynthetic surface by reason of the greater total daily photosynthesis but without altering the basic rate of photosynthesis. The racial differences in needle length, which seem to account for differences in rates of photosynthesis per seedling, must be due to genetic control of either the efficiency of utilization of photosynthates or the apportioning of the utilized photosynthates.

Rooting Slash Pine Needle Bundles

Methods of propagating pines vegetatively, especially by the rooting of cuttings, are constantly being sought as aids in tree improvement studies. In the course of this work, stem cuttings of many species of pine have been rooted with varying degrees of success. Another potentially useful method is the rooting of needle bundles whereby numerous progeny may be produced from a single branch taken from a selected mature tree or from a young seedling hybrid.

At the Athens-Macon Research Center fully developed needle bundles from a 2-year-old rooted slash pine cutting, originally taken from a 1-year-old seedling, were rooted after 2 or 3 months in a 50-50 mixture of sand and peat moss. Three treatments were tested as follows: (1) needle bundles planted 2 inches deep; (2) needle bundles planted $\frac{1}{2}$ inch deep; and (3) needle bundles placed flat on the surface of the medium with the bases covered by moist paper toweling and aluminum foil.

This experiment was carried out during early summer in a shaded greenhouse where supplemental light was used to extend the photoperiod to 16 hours. No attempt was made to maintain high humidity above the rooting medium. Plain tap water was applied daily. All needle bundles were treated with 0.8 percent indolebutyric acid in talc. The greater success of treatments 1 and 3, as compared with treatment 2, shown in the following tabulation, is probably the result of better water absorption by needle bundles in these treatments.

Treatment	Planted (Number)	Rooted (Percent)
1	12	58
2	24	5
3	12	42

The rooted needle bundles were retained and observed for shoot growth. One produced a shoot after 3 months. It is hoped that this problem of top dormancy may be solved satisfactorily to allow use of this interesting method of vegetative propagation in forest research.

Splitting Yellow-Poplar Seedlings

Yellow-poplar is notoriously difficult to propagate by cuttings or air-layering. Another method recently tried shows promise for propagating clonal lines of yellow-poplar seedlings The entire seedling is split, the exposed tissues are coated with lanolin, and the half-seedlings transplanted. Six seedlings were split and planted in a greenhouse under a 16-hour photo-period at the Athens-Macon Research Center in early December. By the end of the month, all 12 half-seedlings had calloused over, new leaders had assumed dominance, and excellent roots had developed (fig. 17).

Figure 17.--At left, half-seedlings shortly after being split. At right, calloused sides of the same half-seedlings 60 days later.

Naval Stores

Naval stores producers are having difficulty in leasing enough slash and longleaf timber for gum production. If this difficulty continues, one alternative is for gum producers to acquire forest land and produce gum as an orchard crop (fig. 18).

Figure 18.--Gum orchards similar to this one with 100 trees per acre at the time of planting could probably grow to turpentining size in 12 years on good sites and produce 3 barrels of gum (1,300 lbs.) per acre per year for 12 more years.

Our present concept of a gum orchard is a plantation of slash pine on a prepared site or on an old field with not more than 100 trees per acre at the time of planting. With this spacing, trees will probably reach commercial chipping size (10 inches in diameter) in about 12 years on good sites. Expected gum yields are about 3 barrels per acre per year, and productive life of the stand will be 12 years (two faces each tree, worked for 6 years).

Looking farther into the future when gum orchards can be planted with superior strains of slash pine having twice normal gum yields, 6 barrels of gum per acre per year can be expected, and the area needed to maintain presentday levels of production can be cut in half.

Effect of Site Quality and Stand Density on Gum Yield

The first step in planning the establishment of gum orchards was a study begun in 1956 to determine the effect of site index and stand density on gum yield of individual trees. This study involved 10 plots and 1,300 trees in a variety of stand conditions.

Partially completed analyses which will involve regressions of many combinations of independent variables on gum yields show several important results. Combinations of significant independent variables are shown in the following tabulation.

Significant variables	Coefficient of determination (r^2)
Diameter and crown length ratio	0.412
Diameter and average width of last five rings	.388
Diameter and reciprocal of stand density	.394

When computations are completed, it is hoped that a reasonably good prediction can be made for gum yields of slash pine at different stand densities.

Site index had no effect on gum yield per tree among trees of equal size within the range studied. This included stands from SI-73 to SI-104. Site index curves then appear useless for evaluating gum productivity for any area. For this purpose we need curves showing the increase in diameter with increasing age at low stand densities.

With such curves, the time required to reach turpentining size can be predicted, and the length of the rotation for a gum orchard can be determined. Existing tables can be used to predict gum yields during the period of turpentining. From these two figures the gum yield in barrels per acre per year could be computed for the rotation.

Effect of Turpentining on Growth

Past studies have shown that in a 20-year-old slash pine plantation, one turpentine face reduced the annual volume increment on the first log of turpentined trees during the period of gum extraction to 74 percent of that for round trees in the same plantation. In an extension of this work, it has been learned that a back face installed after 2 years of work on the front face reduced the annual volume increment of the first log to 59 percent of normal on the turpentined tree, but the reduction to this level was delayed until the second year of back-face work. During the year following the cessation of turpentining, the annual volume increment increased to 74 percent of normal.

This information may be of value to forest managers who because of unexpected complications cannot cut their trees promptly after turpentining is completed.

FOREST ECONOMICS

Forest Surveys Start on Third Cycle in the Southeast

In July 1957, field crews launched a resurvey of South Carolina, thus inaugurating the third survey cycle in the southeastern states. The original surveys were made in the 1930's prior to the war. The second series began in South Carolina in 1946 and progressed through the 5-state area in about 11 years. These periodic surveys provide not only information on current forest area and timber volume but also point out important trends affecting the forest resource. The rate of progress has recently been increased, and the time required to complete the third cycle should be about eight years.

At the end of 1957, field crews had completed work in the South Carolina Piedmont and had made a good start in the northern coastal area (fig. 19). Material assistance is being provided by the South Carolina State Commission of Forestry, the pulp and paper industry, and several of the larger lumber companies.

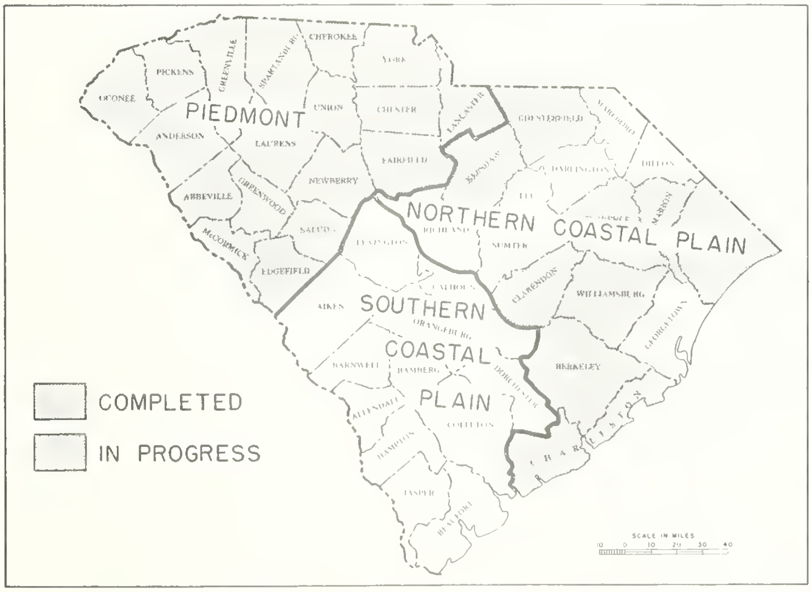

Figure 19.- Progress of field work on the third survey of South Carolina.

Survey Procedure Shifts to Use of Variable Radius Sample Plot

With the beginning of the third Forest Survey cycle, an important change was made in the field method of collecting sample plot data for inventory purposes. Estimates of timber volume and other stand characteristics are made directly from tree tally and measurements taken on sample plots. Plots large enough to comprise an adequate sample of large trees will usually involve a burdensome count of poles and smaller seedlings and saplings. Subplots established within the main plot have been used for many years on the Forest Survey to overcome this difficulty.

In recent years, a sampling technique has come into use which extends this idea of adjusting plot size to tree size by means of a different plot size for every change in tree-diameter class.

Two concepts of this technique prevail. Some foresters like to regard the selection of the trees to be tallied as governed by exclusion or inclusion of the sampling point in a circle surrounding a tree, the size of the circle being related to the diameter of the tree. These foresters refer to the method as "point" sampling. Other foresters see the technique as a series of concentric circles about a selected point, the size of the circle varying with the size of the tree. These people, quite logically, refer to the method as "variable-radius plot" sampling. This difference in concept makes no practical difference in the application of the method.

The success of this technique depends to a large extent upon developing a simple and practical means of selecting trees to be tallied. Many devices have been proposed and tried out, including a number of sighting devices. The wedge prism is perhaps the most popular of these devices, but use of the prism has some disadvantages in brushy country and on steep terrain, where adjustments in plot size are necessary because of slope.

A procedure which overcomes these disadvantages has been developed for use on the South Carolina Forest Survey. It involves only the use of a 1-chain tape. Limiting distances for each 2-inch diameter class and adjustment distances needed for correction of various degrees of slope are painted directly on the tape to guide the crews in selection of trees to be tallied.

This method, in a thorough trial on more than 2,000 plots in South Carolina, has proved highly successful under all types of forest conditions. The new procedure will be described in detail in a Station Paper now being prepared for publication.

Forests Increase by $1\frac{1}{2}$-Million Acres in Virginia

The second survey of Virginia's forest resources, begun in the spring of 1956, was completed in June 1957, and preliminary results are now available. Comparisons of forest area show an increase of more than $1\frac{1}{4}$ million acres, or 8.6 percent, since the original survey of 1940 (fig. 20). Commercial

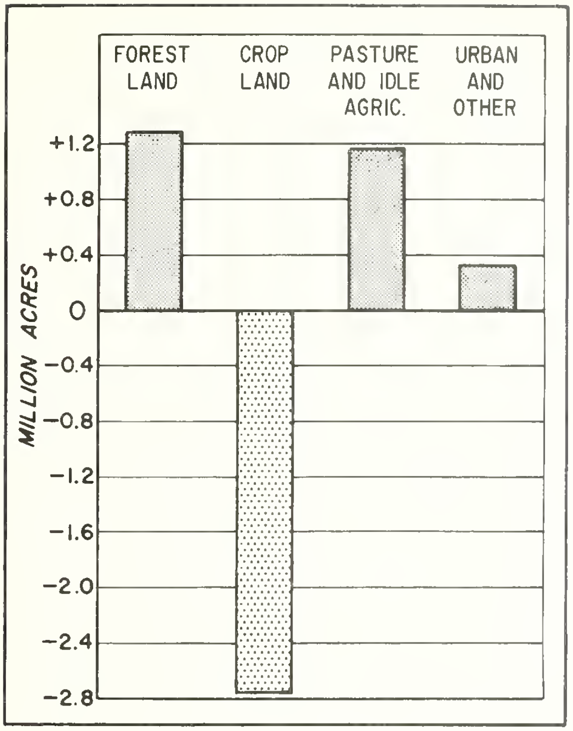

Figure 20.--Change in Virginia land use, 1940 to 1957.

forest area rose 10 percent in the Mountain Region, 7 percent in the Piedmont, and 4 percent in the Coastal Plain. The most spectacular change in land use was the reduction in cropland area, which amounted to 2-3/4 million acres during the same period. Some of this land was converted to pasture, but much of it is now idle or abandoned and is gradually reverting to forest. A 34-percent expansion has taken place in area for towns, suburban developments, highways, airports, and other nonforest and nonagricultural uses.

Comparisons of area by forest type shown in figure 21 are based on type definitions used in the 1940 survey. The upland hardwoods expanded 1.4 million acres, or 19 percent, and the shortleaf pine type dropped 1/3 million acres, or 17 percent. Areas of other types dropped slightly except for Virginia pine, which showed a 7-percent increase. The proportion of commercial forest area in pine and pine-hardwood types changed from 43 percent in 1940 to 38 percent in the resurvey. Forest in upland hardwoods increased from 50 to 56 percent during the same period.

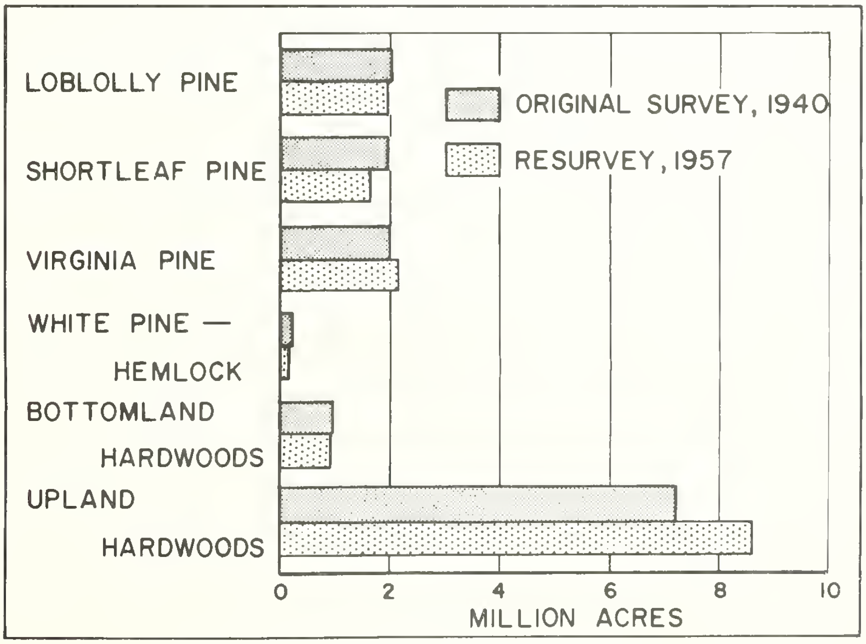

Figure 21.--Commercial forest area of Virginia by forest type, 1940 and 1957.

Net volume in sound trees 5.0 inches d.b.h. or larger was found to be 2 billion cubic feet, or 19 percent greater than in 1940. Softwoods changed only slightly, dropping $2\frac{1}{2}$ percent, while hardwood volume increased almost 35 percent. Softwoods increased a little in the 6-inch and 8-inch d.b.h. classes but fell below the 1940 level in the larger diameters (fig. 22). Hardwoods made large increases through the 18-inch class and dropped off only slightly above the 20-inch class.

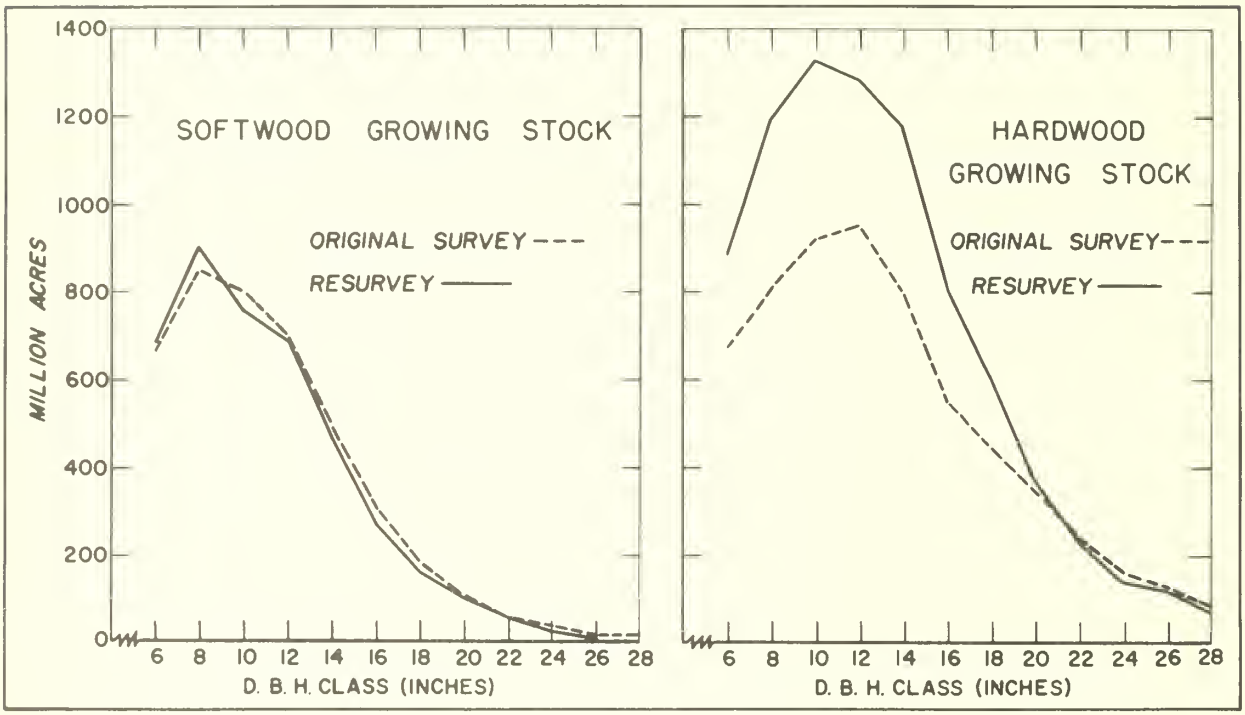

Figure 22.--Comparison of growing stock volume by diameter class.

Softwood sawtimber volume decreased 880 million board-feet during the past 17 years, while hardwood volume rose nearly 5 billion feet (table 9). These changes appear even more significant when tree-size class is considered. Pine and other softwood species show reductions of 4 percent in timber under 15 inches d.b.h. and 13 percent in larger trees. Hardwoods in the small-sawtimber sizes made a spectacular gain of 41 percent, and the volume in larger hardwood trees was up 19 percent.

Table 9.--Change in Virginia's sawtimber volume[1] between surveys

Species group and tree size	1940	1956-1957	Change	
	Million bd.-ft.	Million bd.-ft.	Million bd.-ft.	Percent
Softwoods:				
Under 15 inches d.b.h.	8,946	8,601	-345	-4
15 inches d.b.h. or larger	4,010	3,475	-535	-13
Total	12,956	12,076	-880	-7
Hardwoods:				
Under 15 inches d.b.h.	7,298	10,314	+3,016	+41
15 inches d.b.h. or larger	10,158	12,125	+1,967	+19
Total	17,456	22,439	+4,983	+29
All species:				
Under 15 inches d.b.h.	16,244	18,915	+2,671	+16
15 inches d.b.h. or larger	14,168	15,600	+1,432	+10
Total	30,412	34,515	+4,103	+13

1/ Volumes were recomputed to eliminate differences due to merchantability standards or volume tables used in either survey and thus show valid comparisons. They will not agree with other published estimates of timber volume in Virginia.

Pulpwood Production at New High

Pulpwood use in the South created a record again in 1956 for the seventh consecutive year (fig. 23). A total of 20,345,000 cords including both roundwood and chips from wood residues were received by mills drawing wood from the 12-state area. The new total was 1,956,000 cords higher than in 1955, an increase of 10.6 percent. In terms of physical volume, 20 million cords would make a pile of wood the size of a football field, including the end zones, stacked 8½ miles high. It would cover nearly 15,000 acres with a layer 4 feet deep. It would weigh nearly 60 million tons; and to haul it all at one time would require 3 freight trains stretching from Jacksonville, Florida, to Seattle, Washington.

Pulp chips from debarked sawmill slabs, veneer cores, cull crossties, and other residues are becoming more and more important in the wood procurement picture. Last year 659,000 cords of chips, or 3 percent of the total production, came from these materials.

Behind this increase in demand for wood is a parallel increase in pulping capacity of southern mills. In 1956, the 68 mills located in the Southern Region had a total daily capacity of 38,000 tons of wood pulp. New mills and new equipment raised the 1956 productive capacity of the industry by 12 percent over 1955. It is now 135 percent greater than the 16,200-ton capacity existing ten years ago. With several new mills still under construction and expansion under way in others, the outlook is for still further increases. This may not be true of 1957, however, because of downward adjustments in production made to meet existing market conditions.

Figure 23.--Pulpwood on its way to a southern mill.

The production information was obtained by the Southern and Southeastern Forest Experiment Stations in cooperation with the Southern Pulpwood Conservation Association. Detailed state and county statistics are contained in Forest Survey Release No. 80, published at New Orleans, Louisiana, by the Southern Forest Experiment Station.

Pulpwood Prices Stable at Record Levels

Pulpwood prices are also at an all-time high. During 1957, southeastern pulpwood prices held to the record levels of 1956 in spite of market adjustments that somewhat reduced output of pulp and paper products. The present price plateau was reached after a rise that had been interrupted only twice since the war--in 1949 and in 1953. The only year in which prices actually declined was 1949, and they recovered the following year. These and other trends shown in table 10 are based on reports from 16 representative paper mills that consume 70 percent of all the pulpwood, both pine and hardwood, currently produced in the Southeast.

Three price series are shown in the table--one for wood, f.o.b. railroad cars, one for wood trucked directly to mills, and one for all wood. The rail and truck wood series show trends more clearly than the all-wood series, since the latter reflects not only changes in price but changes in the proportions of rail, truck, and barge wood purchased. On the other hand, the all-wood prices are the ones applicable to total regional volumes of production or consumption.

Table 10.--Average price of rough pulpwood in the Southeast[1]
(In dollars)

Year	Pine			Hardwoods		
	Rail wood [2]	Truck wood [3]	All wood [4]	Rail wood [2]	Truck wood [3]	All wood [4]
1938	3.55	3.85	3.60	--	--	--
1939	3.75	4.40	3.90	--	--	--
1940	4.00	4.60	4.15	--	--	--
1941	4.50	5.00	4.60	--	--	--
1942	5.90	6.65	6.00	--	--	--
1943	7.15	8.00	7.25	--	--	--
1944	8.15	8.70	8.20	--	--	--
1945	8.35	9.15	8.45	8.10	8.55	8.10
1946	9.90	10.75	10.10	9.50	10.55	9.70
1947	10.80	11.70	10.95	9.70	10.55	9.80
1948	11.65	12.30	11.70	11.00	11.25	11.05
1949	10.85	11.80	11.00	10.75	11.25	10.80
1950	11.85	12.55	11.90	10.70	11.50	11.00
1951	13.65	14.70	13.85	12.40	13.15	12.75
1952	13.70	14.70	13.90	12.40	13.15	12.80
1953	13.70	14.70	13.90	12.35	13.15	12.75
1954	13.75	14.75	13.95	12.30	13.15	12.75
1955	14.15	15.05	14.35	12.50	13.45	13.05
1956	15.15	16.45	15.45	12.90	13.90	13.50
Sept. 1, 1957	15.15	16.55	--	12.90	13.95	--

1/ Per cord of 128 cubic feet of 5-foot wood with bark. Includes dealers' allowances in cases where they are paid.
2/ F.o.b. railroad car.
3/ Delivered to pulp mill.
4/ Weighted average of all wood loaded on railroad cars, trucked to pulp mills, and delivered to barge landings.

Minimizing the Cost of Pulp Chips from Small Sawmills

What is the cheapest method of salvaging pulp chips from slabs and edging strips at portable sawmills? To assist in answering such questions, a system of cost analysis was developed and its use demonstrated by application to a typical Piedmont area.[2]

Results indicate that the most efficient way of salvaging volumes up to 190 cords per day is by concentrating rough residues at the pulp mill for debarking and chipping. If the volume required exceeds 190 cords, the central operation should be supplemented by rail yards that process rough residues and ship chips to the mill. The smallest economic rail yard is one with a daily capacity of 25 to 30 cords.

Although debarking and chipping at centralized points are less expensive than the same operations at small sawmills, there may be circumstances under which processing at the sawmill is necessary or desirable. For such cases, the cost analysis showed that if the debarking is to be done at sawmills, money will be saved by chipping the residues there as well.

2/ A. S. Todd, Jr., and Walter C. Anderson. An appraisal of methods for salvaging small-sawmill residues in the southeast. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 84, 35 pp., illus. 1957.

FOREST DISEASES

The increase in tree planting in the South has put a strain on seed supply and nursery production. Thus the cone rust, which often causes heavy losses in slash and longleaf pine seed, has assumed major importance, and nursery diseases that can kill or ruin millions of seedlings in a single nursery within a few weeks must be successfully fought. The planting program has also focused new attention on fusiform rust, white pine blister rust, and Fomes annosus root rot. We are often asked whether diseases are worse nowadays or are we simply more aware of them than we used to be. The answer is, "Both." Some of our huge nurseries and plantations and some of our logging practices invite disease attack. Then too, some diseases such as cone rust have always caused losses but most foresters did not notice them because those losses, intolerable today, were of minor consequences in the early days of forest management.

Figure 24.--Unfumigated bed of 1-0 slash pine in a Georgia nursery; seedlings small and root rotted.

Nursery Diseases

Black root rot, a disease of southern pine seedlings, is being effectively controlled by soil fumigation. Several fumigants have been tried against this disease in Georgia nurseries, of which methyl bromide has been the most useful. It has the multiple advantages of being effective against soil fungi, nematodes, insects, weeds, and weed seeds. The 1957 trials at Albany, Georgia, compared no treatment against the effectiveness of methyl bromide at 1 lb. per 100 sq. ft., Vapam at 100 gallons per acre, and Mylone at 200 gallons per acre. The results (table 11 and figures 24 and 25) show the superiority of methyl bromide in reducing root rot and increasing the production of high-grade seedlings.

Neighboring bed fumigated with methyl bromide prior to planting; seedlings large and free of black root rot.

Figure 25.--Slash pine seedlings from a nursery in which black root rot occurs. These seedlings are 1 year old, and there are 25 in each bundle. Left to right--from untreated bed, from methyl-bromide-treated bed, from Mylone-treated bed, and from Vapam-treated bed.

Table 11.--Effects of some soil treatments on slash pine seedlings at the Herty Nursery, Albany, Georgia

Treatment	Seedlings per sq. ft.	Weight of seedlings per sq. ft.	No. 1 grade seedlings	Plantable seedlings per sq. ft.	Seedlings with root rot
	Number	Grams	Percent	Number	Percent
Methyl bromide	21	314	16	14	0
Vapam	15	226	15	10	48
Mylone	11	185	14	8	65
Untreated	15	175	7	9	80

Year-round isolations from treated and untreated soil showed that, for a time, Vapam, methyl bromide, and steam almost completely eliminated the fungi, bacteria, and actinomycetes from the soil. However, the bacteria and actinomycetes began to increase markedly soon after treatment. The fungus population in steam-treated plots was 8 times normal in 3 weeks. Fungus populations in methyl bromide plots were back to normal in 12 weeks, but in the case of Vapam the fungi were depressed to 5 to 10 percent of normal throughout the study. Ethylene dibromide reduced fungi, bacteria, and actinomycetes only slightly. Pathogenic nematodes were virtually eliminated for the growing season by the treatments. Saprophytic forms repopulated the treated areas rapidly.

Inoculation experiments indicate that Fusarium oxysporum and Sclerotium bataticola play roles in causing root rot, and that their effects, such as cortical hypertrophy (fig. 26), may take place without actual penetration of root tissue by the fungi.

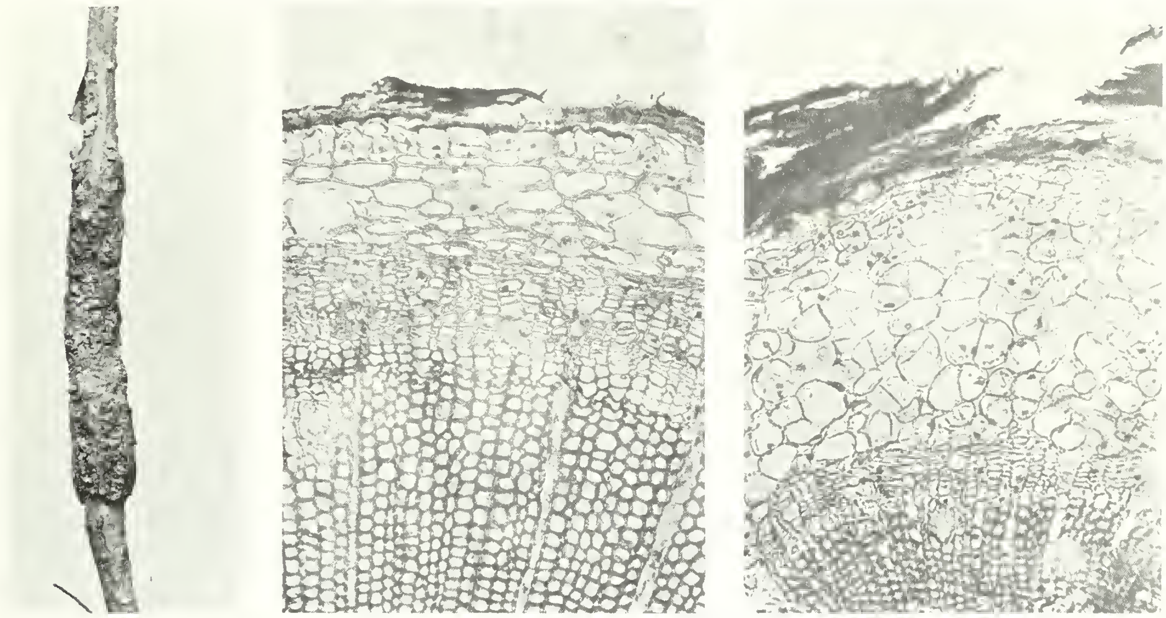

Figure 26.--Left, swollen tissues of a slash pine root affected by black root rot. Center, photomicrograph showing normal root cortex of healthy seedling. Right, hypertrophied cortex in a black root rot lesion.

By timing sprays for fusiform rust with weather conditions at three Georgia nurseries, the same effectiveness ($\frac{1}{2}$ of 1 percent rusted seedlings) was obtained with 3 to 4 sprayings as in beds at the same nurseries that received 10 to 12 sprayings on a regular schedule. An unsprayed area had over 10 percent infection.

Littleleaf Disease of Pine

Studies on many aspects of the littleleaf problem, particularly those dealing with stand degeneration from littleleaf, effects of a wide variety of fertilizers, and effects of eradication, are being terminated. The results of this work have led us into our current program of stand management measures to reduce littleleaf losses and selection for littleleaf resistance. For use in controlled breeding we now have coming into flowering at Athens, Georgia, a large seed orchard of selected clonal material derived from apparently resistant parents. After exposing the shortleaf seedlings to heavy inoculation with Phytophthora cinnamomi and choosing the best survivors, we also have established plantings from selected open and controlled pollinated plants. Littleleaf stands at Union, South Carolina, are being successfully converted to compositions ranging from pure pine to almost pure hardwoods in a test to clarify the relation between littleleaf and stand composition.

There is evidence that the many improved soil characteristics accompanying an increase in hardwood component will reduce littleleaf incidence. New experiments have clearly shown that P. cinnamomi is pathogenic to pine seedlings and that susceptibility to littleleaf may be largely a matter of the rate and extent of recovery of root systems after P. cinnamomi attack.

White Pine Blight

An intensive study of white pine blights was started this year in cooperation with TVA, the University of Tennessee, and the Tennessee Division of Forestry. Through a study of the trees and soils on 14 plots, comparisons are being made of the blighting of white pine in east Tennessee near fume sources with white pine blight in Virginia and West Virginia in areas not exposed to industrial fumes. The symptoms are much alike in all areas, except for earlier shedding of old needles in Tennessee. There was no significant difference in sulfur content of needles among areas. Phases of this study already well along are: soil analyses; fertilizer effects; pruning; sampling of soil and roots for pathogenic fungi, insects, and nematodes; and grafting between diseased and healthy trees to test transmissibility.

Cone Rust

New slash pine, and to a lesser extent longleaf, cones were hit hard by cone rust, Cronartium strobilinum, for the second successive year in 1957. A survey showed attack from South Carolina to south Florida and westward through the Gulf States. In Florida the average cone crop loss to slash pine approached 20 percent, with many trees losing all their cones. The rusted cones also provided breeding material for insects and the insects then moved down to attack maturing cones of the previous year's set, thus compounding the losses.

An intensive study of methods for controlling cone rust has commenced in Florida, with funds contributed largely by eight pulp and paper companies.

Blister Rust Control

Assistance was given the State of North Carolina in scheduling 47 private white pine plantations, containing over 400,000 trees, for examination for ribes bushes, all within the normal ribes range. Bushes were found within infecting distance around 47 percent of the plantings. Technical direction was given the States of Tennessee and North Carolina in the chemical eradication of ribes from 1,513 acres of white pine land.

On the North Carolina National Forests, station personnel scouted more than 3,000 acres for ribes in the vicinity of white pine plantations, mapped 140 acres of control area for eradication cost analysis at 1 plantation, and eradicated 430 ribes at 4 plantations. An informal study was established at one National Forest white pine plantation to explore the feasibility of initially eradicating ribes with 2, 4, 5-T during the dormant season in the Southern Appalachians, and to ascertain the effectiveness of a 300-foot ribes-free zone surrounding the plantation in preventing damaging blister rust infections.

Root Rot

Four eastern white pine stands that had losses from *Fomes annosus* root rot were examined during 1957. They are 30 to 65 years old, and the pines have been growing well. Each stand was thinned about 10 years ago. In some instances, thinning apparently increases root rot by enabling the establishment of *F. annosus* in stumps, from which it spreads into healthy roots.

Oak Wilt

Control measures applied by the State forest services of North Carolina and Tennessee consist of felling wilt trees in summer, ammating the stump, and spraying the trunk and limbs with a mixture of BHC, DDT, and pentachlorophenol in fuel oil (fig. 27). Oak wilt spread as judged by the number of single tree infections was similar in 1956 and 1957 in two North Carolina sample counties. Where control measures are being applied, the wilt is making little or no new headway.

Figure 27.--Treating a wilt-infected tree in North Carolina. This is a twin tree. The left-hand stump is being coated with ammate over the sapwood. The right-hand stump has been ammated and covered with building paper. The trunk and limbs are being sprayed with a formulation of DDT, BHC, and pentachlorophenol.

About 100 North Carolina and Tennessee oak wilt centers found during 1951-1956 are examined annually for further spread within a 300-foot radius. Only 1 of 57 centers that were active and treated in 1956 had a clear case of overland spread near it in 1957.

Fruiting mats on summer-cut wilt trees were more abundant in the spring of 1957 in North Carolina after a relatively wet fall than they were the preceding spring following a drier fall (table 12). If wilting oaks are cut and sprayed in the summer to reduce overland spread, a second spraying early in the spring is advised during wet years.

Table 12.--Oak wilt mat formation by North Carolina trees

Year	Total rainfall August-December	Diseased oaks observed	Stems with mats subsequent January-April
	Inches	Number	Percent
1955	8.9	11	9
1956	15.7	29	79

Although aerial surveys were made of the Shenandoah National Park and the Cherokee, George Washington, and Jefferson National Forests, oak wilt was found only on the George Washington. The areas were controlled. A study of survey effectiveness showed that a method involving two aerial surveys, one in June and one in July, plus ground check of suspects found from the air and examinations of all previously known centers, was effective in locating 85 percent of the currently wilting trees.

Defects in Piedmont Hardwoods

A woods survey involving 1,000 trees selected at random was conducted to obtain information on the prevalence of observable defects in hardwoods in North Carolina, South Carolina, and Georgia. The commonest defect was knottiness. Incidence of other defects is given in table 13.

Table 13.--Defects other than knots in Piedmont Hardwoods

Defect	Trees affected
	Percent 1/
Insect damage	35
Sweep and crook in butt log that reduce board-foot volume	22
Stem diseases	
Cankers	7
Unidentified heart and butt rot after firescarring	5
Other unidentified heart and butt rot	4
Birdpeck	14
Firescar	12

1/ Each percentage is based upon the total number of trees surveyed. Most of the trees examined exhibited several types of defect.

Measurements of internal defects and their relation to external indicators (fig. 28) have been taken on 23 species at 18 hardwood mills. Data from both the woods survey and the measurements of internal defect are now being intensively analyzed.

Figure 28.--A white oak cankered and decayed along its entire bole by Polyporus hispidus. This is one of the most important oak fungi and has the unusual property of causing both cankers and extensive heart rot.

Miscellaneous

Among extensive areas of dying oaks in north Georgia, Virginia, and West Virginia, scarlet oak is most commonly affected. The symptoms suggest the effect of prolonged drought. This or a similar problem is receiving major attention by the Northeastern Forest Experiment Station.

Severe leaf spotting caused by Actinopelte dryina was unusually common on oaks in north Georgia and western North Carolina during the summer.

Needle fascicles from both seedling shortleaf and slash pines were successfully rooted in a mixture of sand and peat moss after they had been treated with indolebutyric acid. Results of this interesting development are described on page 23. Needle fascicles have also been air-layered (fig. 29). All these methods are an aid in tree improvement studies.

The alternate stage of the Virginia pine stem rust was found to be Buckleya distichophylla, and the rust renamed Cronartium appalachianum.

The pitch canker disease, caused by Fusarium lateritium pini, is causing economic losses in many stands of South Florida slash pine near La Belle, Florida.

Figure 29.--Complete little tree produced by air-layering shortleaf pine needle fascicle. Air-layering continued 65 days, followed by 48 days in soil-sand mixture to break dormancy of the apical meristem in the base of the fascicle.

FOREST INSECTS

Insects Destructive to Flowers, Cones, and Seeds of Pine

That insects cause damage to the seed crop of pine has been evident to entomologists for some time. A few felt that the damage was of economic importance, but it was not until the recent expansion of the planting program and the increased activity in tree genetics that research on the subject became essential.

Research on insects affecting flowers and cones was increased this year at Lake City, Florida, following the planning and preliminary work of last year. Three species of the destructive Dioryctria cone moths have been identified, along with a number of other insects including parasites (figures 30 and 31). A rearing technique has been developed for one species of Dioryctria and methods of inducing attack on cones have been devised. Life history studies have commenced. Plans are under way to obtain figures on the economic losses caused by the cone insects, and laboratory screening tests have been planned to evaluate insecticides for control of the primary insects. Interest in methods of control is rapidly increasing, as shown by the number of preliminary airplane spraying tests already conducted by pulp and paper companies to determine whether insect damage to cones can be reduced.

Cooperative Surveys

Cooperative survey activities in other southeastern states with all forest managing agencies are gradually being developed. In fact, a semiannual survey program has started in Florida in cooperation with industry and the Florida Forest Service, and already these systematic aerial surveys of the major commercial forest lands are providing excellent data on timber losses, insect detection, and information on insect-susceptible areas.

Southern Pine Beetle

A proposed program for southern pine beetle research was prepared during the year as a guide in selecting studies for research. Attention was centered on the causes predisposing a stand to beetle attack and on efforts to develop methods of rearing the beetle.

In western North Carolina, northwestern South Carolina, northeastern Georgia, and eastern Tennessee, many beetle infested areas on federal lands were visited during the past summer, and data gathered on stand density, site index, age, and other site and stand characteristics. Southern pine beetles seemed to attack pine stands growing under average field conditions. The stand density of most infested areas was very high in comparison with the site index involved and, consequently, a very slow growth rate prevailed. Exceptions occurred, of course, in the case of recent cuttings, where the

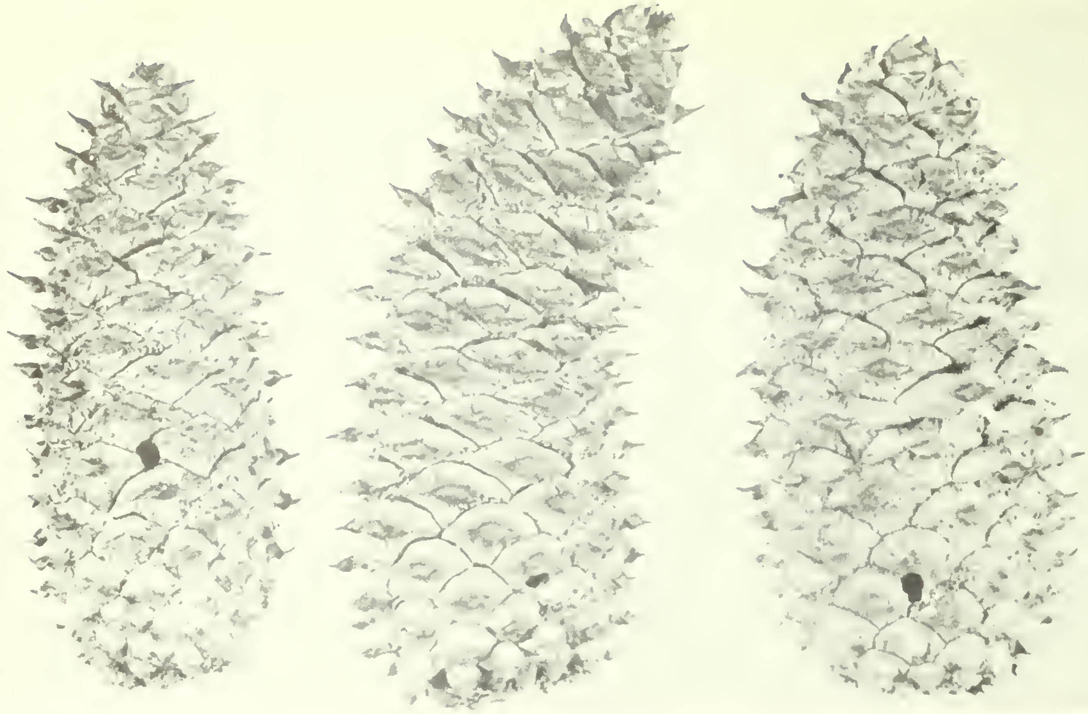

Figure 30.--Cones infested by the cone moth Dioryctria amatella. Note holes made by the emerging adult.

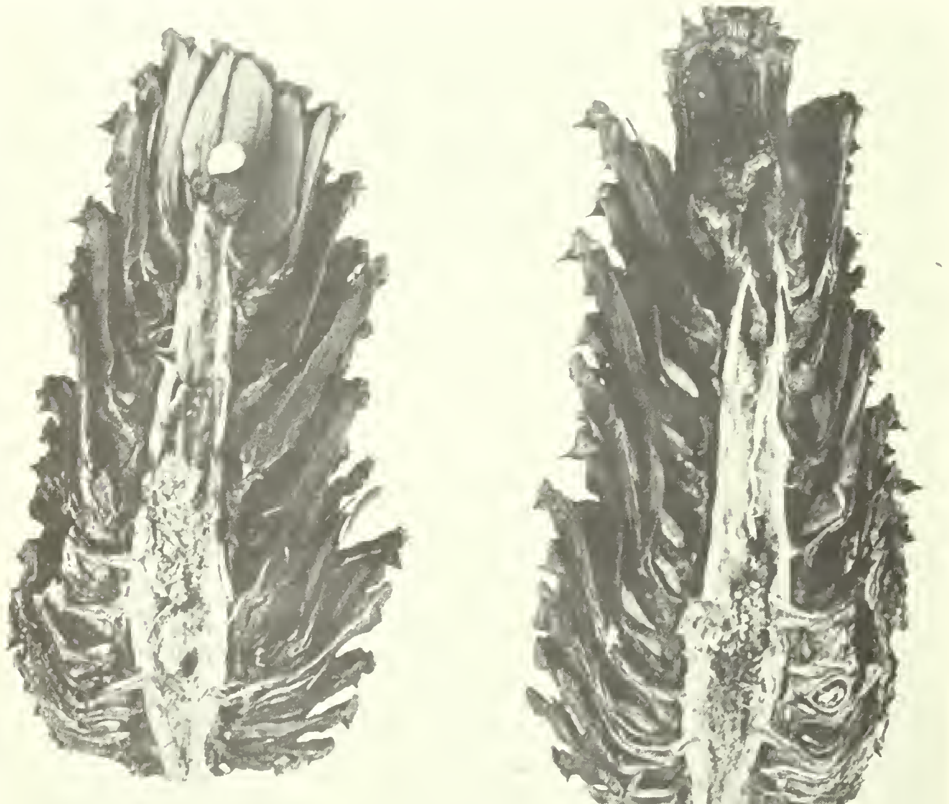

Figure 31.--Sectioned pine cones showing damage to cone and seed caused by Dioryctria amatella.

densities were quite low. However, it is doubtful whether the cuttings occurred far enough in advance of beetle attack to have had much beneficial effect on the trees. Sixty-eight percent of the attacks were located in areas containing 75 percent pine or over, and the great majority of the attacked trees were between the ages of 30 and 70. This age group seemed to predominate in the areas visited. All of these data were gathered on areas classified as epidemic.

Some valuable leads were gained from efforts to rear large populations of the southern pine beetle. Attacks were forced on short pine bolts under a variety of conditions and also on standing trees. Seldom were the forced attacks equal to those attained under natural conditions. Emergence was also low in comparison with that under natural conditions. When emergence was low, regardless of the degree of attack sustained, the larval galleries were abnormally long and the larvae died before reaching half their mature growth. High moisture content of bark may have caused this behavior. Normal and abnormal larval galleries are shown in figure 32. Results of these experiments will be used in planning future studies.

The beetle outbreak in the Southern Appalachians continued for the fifth consecutive year. The infestations, centered in western North Carolina, eastern Tennessee, northeastern Georgia, and northwestern South Carolina, seemed less aggressive than in 1956. In many areas a decline was evident.

Although losses were generally less on Forest Service and private lands in the epidemic area, attacks in the Great Smoky Mountains National Park were heavier and more extensive than in 1956. During 1957 it was estimated that 13,000 trees were killed on the control units of the Park, and probably a greater number were attacked in the surrounding areas.

Records of chemical treatment on trees infested with the southern pine beetle show 33,080 trees treated with benzene hexachloride and fuel oil during the year. Current survey estimates are not available, but most control areas have infested trees in need of treatment.

Ips Engraver Beetles

A short-lived but very destructive outbreak of Ips beetles occurred during June and July in the east central portions of Virginia and North Carolina and in northeastern South Carolina. The outbreak was not continuous throughout these areas, but scattered broadly over the region as outlined on the accompanying map (fig. 33).

The outbreaks began in early June in the southern portion of the infestation area, developing a little later in the northern extremities. Ground and aerial observations suggested that, after one initial and tremendous increase in beetle populations, the outbreak came to a sudden halt for reasons as yet unknown. Examination of the initial groups of killed trees show (a) beetle broods were frequently not produced by parent beetles of the initial high population, (b) broods often failed to develop beyond the small larval stage, and (c) adult beetles that did develop failed to emerge.

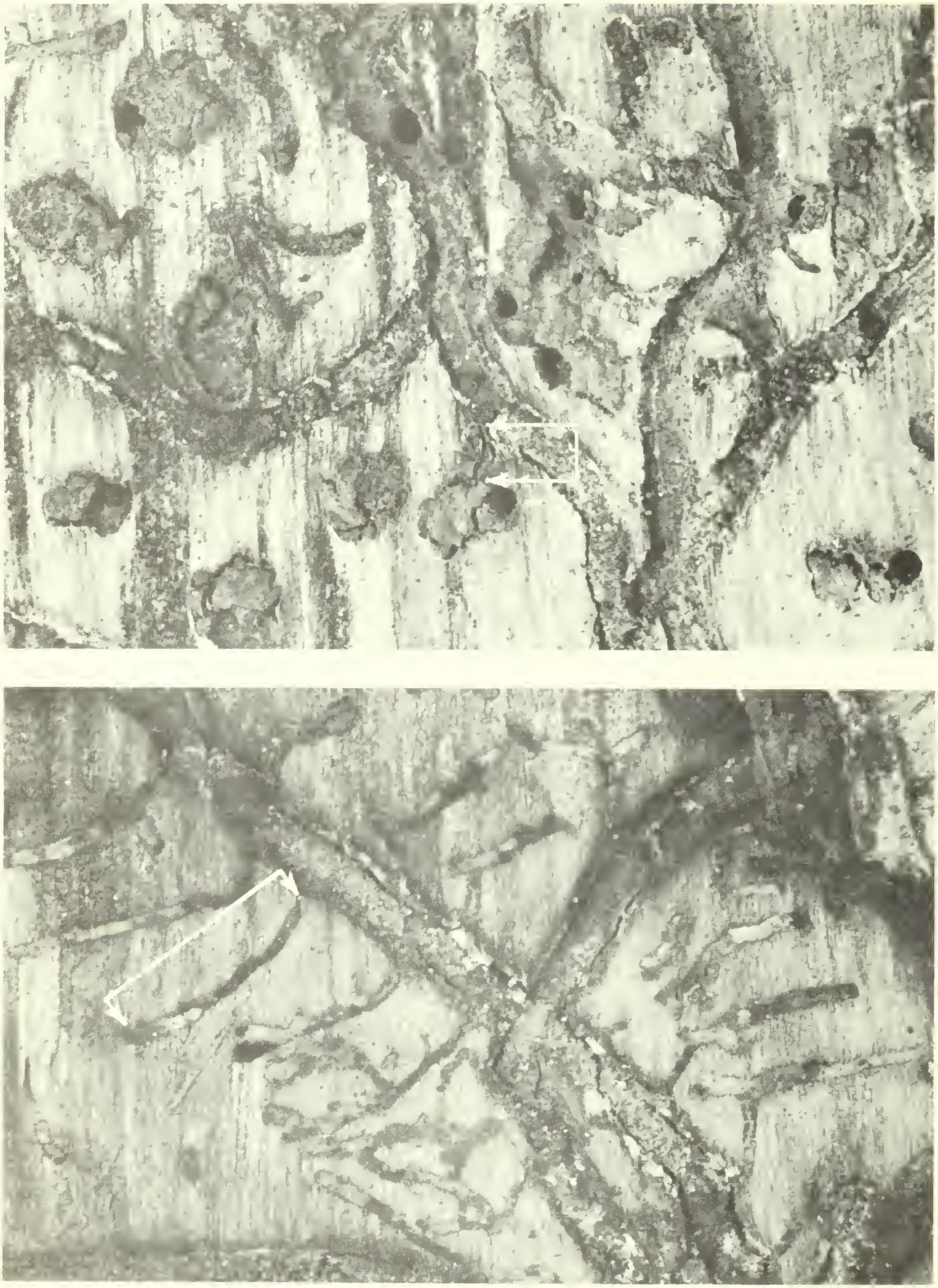

Figure 32 --Above, infested bark of shortleaf pine showing normal larval galleries occurring under natural conditions. Below, the long abnormal larval galleries occurring under experimental conditions.

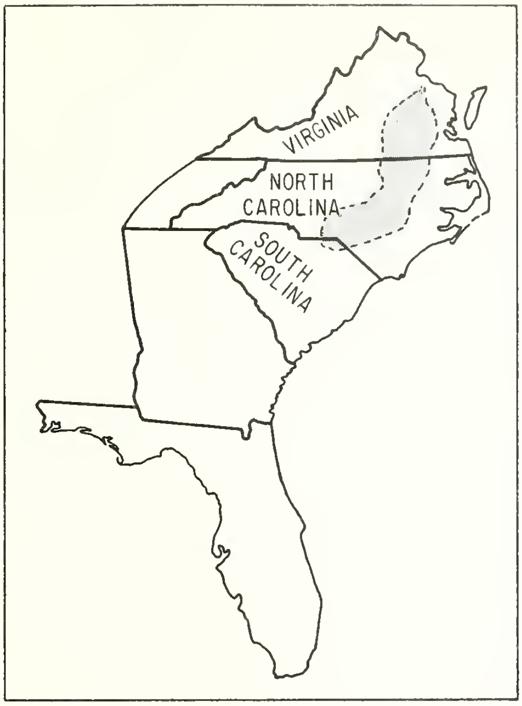

Figure 33.--Shaded area indicates Ips beetle epidemic, June-July 1957.

During the short period that Ips was in outbreak status in east central Virginia and North Carolina and northeastern South Carolina, it is estimated that about 10 million board-feet of pine, chiefly loblolly, were killed.

In Florida, Ips beetle populations which developed in scattered lightning-killed pines emerged and caused light losses during the fall of 1957.

Black Turpentine Beetle

Turpentine beetle control came to a standstill on the Osceola National Forest in Florida during the year. Beetle activity died down considerably in other parts of north Florida and south Georgia. Scattered reports of light damage were received from other parts of the southeast. In North Carolina, aside from a small but very vigorous outbreak in the southwestern part of the State, the only area suffering from a full-scale beetle outbreak was on the Hoffman Forest in the vicinity of New Bern, where continuous logging of pond pine in pocosin type south of New Bern has maintained high but fluctuating beetle populations. Early in the year, turpentine beetles were declining. Populations remained low until midsummer. Since then they have increased and in some logging units most of the residual trees have been killed. In contrast, uncut stands across the road were unattacked.

Research on the black turpentine beetle has been temporarily halted because of the pressure of other problems. While a number of questions remain unanswered, particularly with respect to the biology and behavior of the beetle in relation to its environment, the major objectives as related to satisfactory control have been attained.

Pales Weevil

The pales weevil, Hylobius pales, and associated weevils kill recently planted pine seedlings by chewing the stem bark. Reports of severe damage and seedling mortality on cutover lands in the South have become common during the past 9 years. This increase in damage is associated with changing forest practices rather than with any changes in biology or behavior of the insect. Reports of weevil damage began to come in soon after forest practice indicated that it was economically feasible to keep pine lands in continuous production by cutting and immediate planting rather than by waiting for natural

restocking. On such plantations, it is becoming increasingly evident that the weevils are causing a great deal of mortality formerly attributed to drought and other causes. The fact that the weevil's life cycle, and especially its feeding behavior, coincides closely with planting schedules makes the problem more severe.

This Station during the past 3 years has screened several promising insecticides for use against Pales weevil in areas newly planted or about to be planted. As a result, dipping seedling tops in a 2-percent aldrin-water emulsion is now recommended as a treatment to prevent weevil attack. Cost of treatment is 10 to 15 cents per acre. Other protective treatments, once the seedlings have been planted, include aldrin and heptachlor as emulsion sprays and the application of heptachlor in granular form around the bases of the seedlings. Further tests will determine whether concentration of the most promising materials can be reduced to lower treatment costs and whether methods of treating planting stock can be improved.

Elm Spanworm

Defoliation of hardwoods by the elm spanworm (formerly snow-white linden moth), *Ennomos subsignarius*, has increased from 50,000 acres reported in north Georgia in 1956 to 300,000 acres in north Georgia, southwest North Carolina, and southeast Tennessee.

A preliminary study was carried out in Georgia to determine (1) the effect of the defoliation upon the growth of oak and hickory and (2) if growth changes occurred simultaneously along the entire bole of the tree. The sample trees were located in an area which has been heavily defoliated each spring for the past three years (fig. 34).

Five hickory and seven oak trees from 45 to 65 feet tall and from 8 to 20 inches in diameter were felled and sections taken at stump, midbole, and base of the crown heights. Growth was determined by averaging two increment measurements on each section.

Graphs of the growth data for the years 1952-1956 showed that 10 of the 12 trees had less growth in 1956 than in 1955 on all three bole sections. An oak and a hickory had each increased growth in one portion of the bole while growth was simultaneously decreasing in two other parts.

Following completion of this preliminary work, a study to determine the growth loss of several hundred trees located throughout the defoliated area was commenced.

A pilot test is being considered to determine the best methods of controlling the insect in high-value areas.

Figure 34.--Hardwood stand defoliated by the elm spanworm, Ennomos subsignarius, in northern Georgia.

Field Insectary Added to Research Facilities at Lake City, Florida

An expanding forest insect research program at the Lake City Research Center and an increasing need for insect rearing facilities resulted in the construction of a field insectary at the Olustee Experimental Forest (fig. 35). The wood frame building was designed and oriented to minimize drastic variations in temperature and humidity within the structure. Adjustable slatted basswood curtains protect the rearing cages from direct sunlight and driving rains.

Figure 35.--Insectary at Lake City Research Center for study of insect biology and control.

FOREST FIRE

Program Greatly Expanded

A major and much needed expansion in forest fire research in the South was made possible this year by increased federal appropriations plus substantial cooperative contributions provided by the Georgia Forestry Commission and Georgia Forest Research Council. Field headquarters for this expanded program have been established at Dry Branch, near Macon, Georgia, in office and laboratory facilities provided by the Georgia cooperators.

Even though located in Georgia, personnel will conduct a broad regional fire research program aimed at solution of major problems of the South. The following research projects are planned:

> Studies of suppression techniques. At the beginning this will involve the testing of chemical fire retardants (fig. 36) and their delivery by means of ground and aerial tankers under southern forest and fuel conditions (fig. 37).
>
> Studies of prescribed burning. The purpose of the project is to determine the conditions of stand, fuel, and weather under which it is most practicable to prescribe burn for specific purposes with a minimum damage to desirable vegetation.
>
> Development of a drought index. A method of appraising the severity of drought conditions in both organic and inorganic soils is needed as an addition to the system of measuring fire danger now universally used in the East and South.
>
> Fuel classification. Studies to determine the rate and amount of energy release of different fuels burning under different weather conditions as they affect fire behavior.
>
> Fire-weather forecasting. An experienced meteorologist on assignment from the U. S. Weather Bureau has been stationed at Dry Branch, where necessary facsimile and teletype equipment are available. During the fire season he will make daily fire-weather forecasts for the State of Georgia and at other times will assist in phases of prescribed burning and other studies where a knowledge of meteorology is essential.

Because of extremely severe ground-burning fires in the pond pine type of eastern North Carolina in recent years, plans are being prepared for cooperative fire research with the North Carolina Division of Forestry and pulp and paper companies. Highly flammable fuels, long-distance spotting, poor trafficability for present mechanized equipment, and extremely stubborn and deep burning fires in peaty soils make fire suppression in the area exceedingly difficult.

Another aspect of fire in this section is its possible use in regenerating pond pine. The main difficulty lies in obtaining a prescribed fire of the right intensity, yet holding it within desired bounds. Unless means can be found to measure fuel and burning conditions more accurately, prescribed fire as a silvicultural tool does not appear promising.

Figure 36.--Sodium calcium borate applied to palmetto and grass fuels has stopped this test fire.

Figure 37.--U. S. Forest Service plane (ex-Navy TBM) making a test drop in Georgia as part of experiments with chemical fire retardants.

Fire Behavior

Our continuing study of fire behavior, principally of those fires exhibiting extreme characteristics, is contributing materially to a better understanding of the over-all fire control problem. Some aspects of fire behavior are discussed in the following paragraphs.

Nocturnal Low-Level Jet Winds

A good many of the worst forest conflagrations have occurred at night. Some thought has therefore been given to nocturnal low-level jet winds and their possible significance in fire control and crew safety. Since the stabilizing of the lower atmosphere is a major factor in the development of these winds, their growth may start shortly before sunset, when surface cooling sets in. The wind speed maximum is most likely to be in the zone between 1,500 and 2,500 feet above the valley bottom or general lowland level, and the danger zone for night fires has a somewhat wider elevation range--probably from about 1,000 to 3,500 feet above the lowland level. The elevation ranges for these zones merely represent the most probable values because they actually vary somewhat from night to night. Occasionally the jet maximum is less than 1,000 feet, or it can be more than 4,000 feet, above the lowland level--and the elevation of the danger zone is changed accordingly. Also, the elevation of the jet maximum has a tendency to increase somewhat during the night.

The nocturnal low-level jet appears to build up most rapidly shortly after sundown, and it may continue at a somewhat slower development during the night. However, the worst burning conditions usually occur before midnight. It may be that increasing relative humidity and fuel moisture after midnight offset any further development of the low-level jet.

Probably one of the most definite warning signs of the possible later onset of the nocturnal low-level jet is low wind speeds aloft during late afternoon in the zone between 4,000 and 8,000 feet above the pilot balloon station or lowland level. If this condition is followed by increasing wind speeds at 1,500 or 2,000 feet near sundown, it is likely that the nocturnal jet has started to build up.

Shape and Motion Characteristics of Convection Column

After a convection column has formed, the blowup may have already occurred or at least be well under way, so the characteristics of the column may be more significant from the standpoint of safety than for fire control efforts. Well-developed convection columns have fairly definite motion and shape characteristics which are good indicators of the intensity and behavior of the fire.

Motion or pronounced movement of the convection column gases is a more immediate indicator of high fire intensity than is convection column shape. Since the center of the convection column is not visible, the updraft velocity in the hot central core is not known, but it may exceed 70 or 80 miles per hour on high-intensity fires. However, a fire often burns in surges, in which case huge bubbles of hot gases can be seen to travel rapidly upwards in the column. These surges are accompanied by an outward and downward roll in the column's outer periphery. These rolls may be present far up into the convection column, which over a high-intensity fire appears to be continuously turning itself inside out. Color changes as well as motion are indicative of the onset of high-intensity burning. An increased burning rate means a drop in combustion efficiency which, in turn, results in much darker smoke with a dense, solid appearance.

The shape of a well-developed convection column is a good indicator of the winds aloft. If there is a low-level jet wind with a fairly deep zone of decreasing wind speed, the convection column will tend to curve upwards slightly throughout the zone. If the speed of the winds above this zone is sufficiently low, then the convection column will tower to a great height and form a white water-vapor cap. If above the zone of decreasing wind speed there is a rapid increase in wind speed, the convection column will fracture, lose its updraft velocity, and tend to drift horizontally. An observer can anticipate the direction in which spot fires are likely to occur by noticing the direction in which the upper part of the column tends to lean and also the direction of smoke drift aloft if the column fractures. Spotting can occur on a large scale with either the towering or fractured type of column, but seems to be worse with the latter type.

Because of extraneous smoke and lack of perspective, shape and motion characteristics of the convection can be observed better at a distance of several miles than at close range, although the direction of lean and the smoke drift aloft can sometimes be observed from nearby.

Smoke Plumes

The large majority of fires will not form true convection columns but will form smoke plumes. These are indicators of low-intensity burning. When there is considerable wind, the smoke plume will be a light-colored wedge of smoke reaching the ground and drifting downwind from the fire. When the wind is light, the smoke plume may extend upward with its general outline resembling that of a convection column. The most distinctive features of a smoke plume are lack of noticeable vertical motion, relatively light color, and relatively low density.

The Pond Pine Fire

As an example of our case history studies of high-intensity fires, a fire that burned an estimated 5,000 acres during an 8-hour period following 2 p.m. on May 9, 1957, is briefly described.

The so-called Pond Pine Fire started in Tyrrell County, North Carolina, in a flat, swampy, organic soil area. Although surface fuels were fairly dry, neither the Buildup nor Burning Indexes were considered as critical. The same was true of relative humidities and surface winds. In short, there was little on the surface to indicate that an explosive, high-intensity fire would develop.

The fire started at 10:45 a.m. and almost from the beginning had a tendency to spot for short distances. About two hours later, backfires were started from highways, but, before they could burn an effective distance, the main head spotted for several hundred feet over one of the highways. A convection column was now strongly developed. At about 4:15 p.m., the fiercely burning fire spotted across a second highway and continued as a firestorm at a rate of 5 miles in three hours. According to a plane observer, the head reached maximum intensity at about 5 o'clock. At that time spot fires were being set as much as 3/4 mile ahead of the main front. The convection column was of the towering type with a white condensation cap. The height to the base of the cap was estimated at 4,600 feet and to the top 7,300 feet. At about 10:00 p.m. a backfire and high relative humidity stopped the head.

The unusual characteristics of the fire can most reasonably be explained on the basis of winds aloft. Three upper air U. S. Weather Bureau Stations, Raleigh, Cape Hatteras, and Norfolk, form a triangle with the fire area roughly in the middle. Because soundings on May 9 at all three stations agreed closely as to wind velocity and direction profiles, it seems safe to assume that the same conditions prevailed over the fire. A composite of upper air soundings from the three stations in figure 38 indicates a dangerous wind profile with a low-level jet and decreasing winds aloft highly conducive to the formation of a strong convection column and long-distance spotting of firebrands.

This Pond Pine Fire is another in a growing list of case histories that strengthen the concepts originally advanced by the Division several years ago, i.e., the significance of the wind profile in blowup fires.

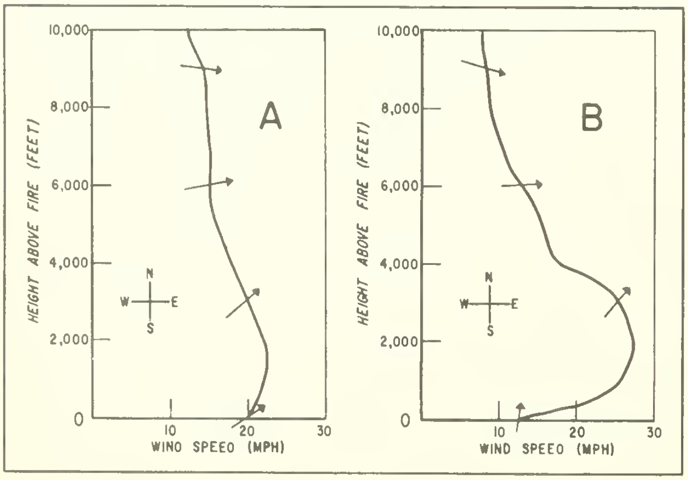

Figure 38.--Estimated wind profile curves in the vicinity of the Pond Pine Fire on May 9, 1957. The curves are composites of the upper air soundings from Raleigh and Cape Hatteras, North Carolina, and Norfolk, Virginia. Composite wind directions aloft are indicated by the arrows. A represents conditions at 3:30 p.m. and B at 9:30 p.m.

State Analysis Reports

Individual analysis reports giving the relation between fire occurrence and burning index were prepared for 13 northeastern states. This is the fourteenth in a series extending back to 1943. In addition, a similar analysis and report for 1956 was prepared for the State of Tennessee, the first of such reports for any state in Region 8 territory.

Burned Area Rate

For appraising the relative progress in reducing the area burned by forest fires, a method that takes into account the prevailing weather has been developed for 13 northeastern states. Briefly, the procedure is to compute a Burned Area Rate by dividing the number of acres burned on state-protected lands by the annual statewide burning index (in thousands). For comparative purposes, and in order to account for large differences in protected area and expansion that has occurred in some states, the Burned Area Rate is computed on a basis of million acres protected. The example in figure 39 is a 3-year moving average of the Burned Area Rate in Pennsylvania, 1943-56 data.

A decreasing Burned Area Rate, especially if a downward trend is maintained for several years, is tangible evidence of a corresponding decrease in the relative area burned by forest fires for a similar amount of fire danger.

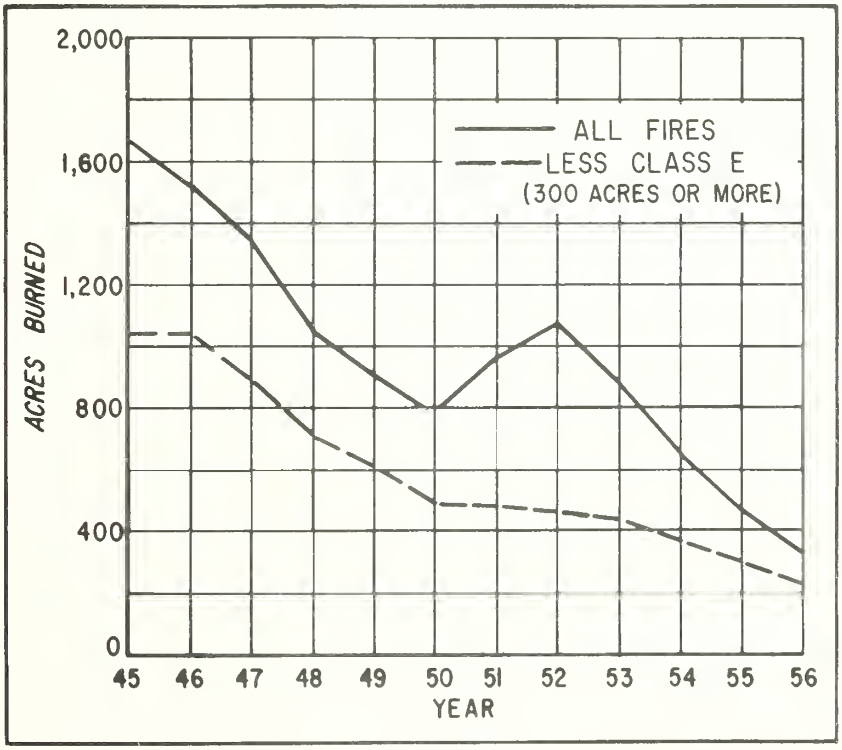

Figure 39.--Burned area rate--number of acres burned per 1,000 units of burning index, per million acres protected in Pennsylvania. Three-year moving average, 1943-56.

The reasons behind the decrease, whether from such factors as successful fire prevention, faster and more energetic initial attack on high danger days, or increased use of equipment, would have to be determined by other criteria.

The Burned Area Rate in figure 39 is shown for all fires (solid line) and for all fires less Class E fires of 300 acres or more (dashed line). The space between the two lines on the graph, therefore, represents the "escape fires," the 1.4 percent of fires that reached Class E size and burned 40 percent of the area in the 14-year period. Both lines show a distinct downward trend, although the dashed line, which may be considered the basic Burned Area Rate, is more consistent. The hump in the solid line, 1951-53, was caused by a few major fires that exceeded 1,000 acres each. Even though the Burned Area Rate for all fires was less in the 1951-53 period than for the early years of record, the evidence is that during periods of prolonged drought and high fire danger an all-out effort is required to hold down the Burned Area Rate.

Fire Training

In 1957 a task force was appointed by the Chief to study ways the Forest Service could strengthen its efforts to prevent fire fatalities. It reported that from a review of 16 tragedy fires a factor that appeared to be present on all but one of the fires was, "...fire behavior which was not expected by the men who were trapped." Subsequently, the Chief of the Forest Service directed that all bosses from crew boss up should have special training in fire behavior and disaster conditions.

As mentioned earlier, study of fire behavior and particularly of blowup fires has been a major project of the Station's Fire Research Division for several years. This past year a special effort was made to draw together the results of our research on fire behavior and closely related subjects in the form of lesson plans and other media.

Specifically, lesson plans were prepared by cooperator J. J. Keetch on four subjects: the factors associated with extreme fire behavior, characteristics of high-intensity fires, warning signals and their interpretation, and the prediction of specific conditions contributing to extreme fire behavior. G. M. Byram, of the Division, prepared two chapters in manuscript form titled, "Combustion of Forest Fuels" and "Fire Behavior," for a forthcoming textbook on fire control by Dr. K. P. Davis, of the School of Natural Resources, University of Michigan, and an article in Fire Control Notes, "Some Principles of Combustion and Their Significance in Forest Fire Behavior." T. G. Storey and Byram prepared a key to vertical wind profiles and associated fire behavior in flat country, and Storey developed lesson plans on principles of fire danger rating systems, application of fire danger measurements and principles of ignition, combustion, and fire behavior. In addition, Byram prepared a chapter on "Upper Winds," and Frank Hood of the U. S. Weather Bureau and Keetch a chapter on "Fire Weather Observations" for the proposed Fire Weather Handbook.

FOREST UTILIZATION

Log and Tree Grade Studies in Southern Pine

During the past year, field work was completed on the southern pine log and tree grade project in cooperation with the Southern Forest Experiment Station and Region 8 of the Forest Service. Over 1,300 logs of shortleaf in Arkansas, loblolly in Mississippi, and longleaf and slash pine in Florida were diagramed, graded, sawed, and the lumber tallied.

In addition, 25,000 IBM cards representing each board and log in the study were punched. This included punching cards for the earlier Santee and Hitchiti studies conducted in South Carolina and Georgia. Analysis work so far has produced quality indices and grade yields for the five study locations. The quality indices and grade yields were by study location, log grade, species, diameter, and condition class. A preliminary test of the applicability of the interim log grades in Arkansas, Mississippi, and Florida is being made.

One aspect of the study was the regrading of every pine board after kiln drying. This was done in order to obtain information on the amount and kind of degrade obtained as a result of kiln drying. With trees and logs completely diagramed in respect to visible features such as compression-wood rings on the log ends, it may be possible to relate board degrading features to log characteristics.

Regrading of lumber after kiln drying entailed work of a tedious and time-consuming nature. Each board had to be identified on the ends with tree number, log number, board number, and green grade before kiln drying (fig. 40). In this manner the change in grade after kiln drying, if any,

Figure 40.--Identification of boards as to tree and log number and lumber grade prior to kiln drying.

and the cause were tabulated. Data are now available giving every board's green and dressed grade with degrading causes, and every board in turn is identified with its respective log and tree.

Charcoal Studies

An additional 10 charcoal burns, for a total of 23, were made in the 7-cord masonry block kiln located at Athens, Georgia. For comparative purposes half of the research kiln is constructed with a double wall with the space between the two walls filled with dirt. The other half of the kiln is a reinforced single wall. After the twenty-second burn the inner double wall had to be replaced because of excessive inward bulging. The new wall section is reinforced with steel rods, a change from the original.

The primary objectives of the charcoaling study during the past year were twofold: (1) For green wood develop operational procedures and obtain charcoal yield data, and (2) develop safety devices for the kiln. The safety features include an automatic device for closing the air intake of the one remaining open airport (fig. 41) in case of excessive kiln "puffing" or smoke blowback. This puffing is an indication of the development of gases, and these gases have sometimes caused kiln explosions. Another device automatically closes the chimney after it becomes inactive in the late stages of the burn and fire develops near the chimney port. These features reduce the possibility of kiln explosion and permit the kiln to remain unattended for the greater part of the burn.

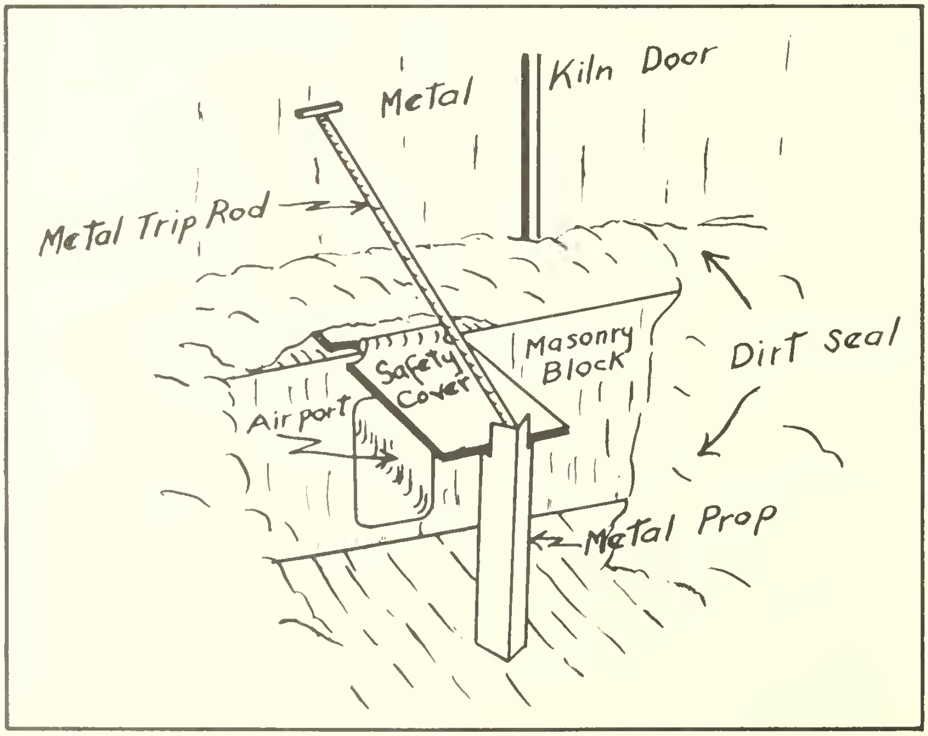

Figure 41.--When explosive gases accumulate in the kiln, puffing develops and vibrates the metal kiln door, pushing metal trip rod against prop, thus letting safety cover fall and cutting off the air supply. This reduces the danger of kiln explosion.

The data collected thus far indicate no significant differences in charcoal yield between coaling of dry wood and green wood. This result is so contrary to popular opinion that additional burns are needed to substantiate it.

Of interest also are the temperature fluctuations obtained during a burn while the air intake remains a constant 15 square inches. Shown in figure 42 are the varying temperature patterns after the tenth hour from burn to burn even though the species, moisture content, and air intake are the same. Because of such fluctuations it will probably be very difficult to standardize coaling procedures or predict charcoal quality or yield.

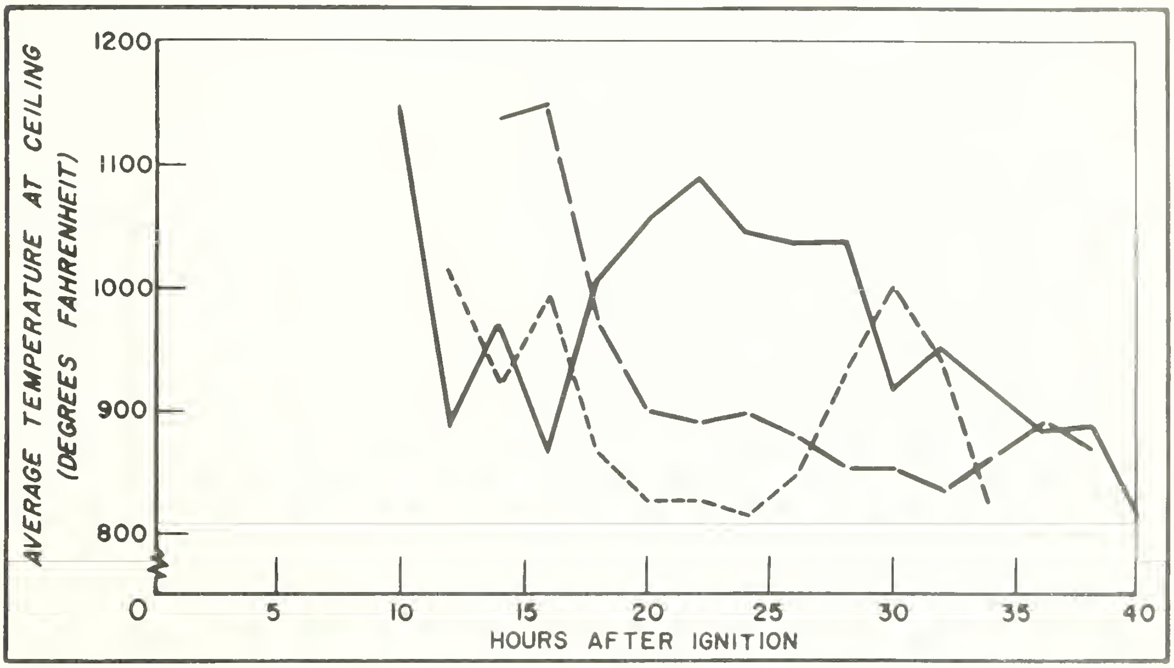

Figure 42.--Temperature patterns for 3 burns of green oak (68 to 72 percent moisture content), with 15 square inches of air-intake port open.

In cooperation with the Forest Products Laboratory the report, "Production of Charcoal in a Masonry Block Kiln--Structure and Operation," was published. Most of the basic operational data were obtained from the Athens kiln.

Seasoning Studies

The study pertaining to the predrying of 1-inch southern pine and hardwood lumber using only high air velocities is being continued at Athens, Georgia. The air velocities used in the tests were approximately 150, 500, and 1,000 feet per minute through the lumber load. The air temperature was held at about 80° F. The lumber was graded before and after drying to determine the degrade due to seasoning. During the year one load of oak was dried from 90 to 15 percent moisture content in 57 days using an air velocity of 500 feet per minute with less than 1 percent seasoning degrade. Six loads of pine

were dried at the three mentioned air velocities. It was found that if the outside air condition is not too cold or relative humidity too high, southern pine can generally be dried to 18 percent moisture content in 6 to 9 days with very little degrade. At present, the tests indicate that an air speed of approximately 500 feet per minute is the most desirable speed to use. However, additional tests are needed to eliminate some of the variables presently not controlled. Three wind tunnels, 4 feet square and 8 feet long, were constructed so that 3 predrying tests could be made simultaneously and therefore subjecting the lumber to the same weather conditions. One of the variables for each set of tests will be air speed. These tunnels were installed under a pole shed and are now ready to be used.

Predrying tests are being made in a wind tunnel on round ash dimension stock. The test blanks are $2\frac{1}{2}$ inches in diameter and 40 inches long. At an approximate average air velocity of 250 feet per minute at room temperature, it required 34 days to dry the stock from green (37-42 percent) to an average of 15 percent moisture content. There was no seasoning degrade.

A study to determine the rate and uniformity of drying of southern pine lumber by four methods of stacking was made at a Georgia seasoning yard. A complete analysis of the data has not been made. Preliminary information indicates that for 20 tests of four piling methods, an average of 25 days is required to dry the 4/4 pine lumber from green to 18 percent moisture content. As shown in figure 43 and based on the data to date, air seasoning takes considerably longer than predrying. A detailed study was also made of the air seasoning practices at 20 Georgia lumber yards. Moisture content readings were made on 1,347 boards dried by four stacking methods: flat piled, package piled, end piled, and crib piled. It was found that there was considerable lack of uniformity in moisture content of the piles studied. The percent of boards above 19 percent moisture content for each stacking method were found to be as follows: flat piling, 3 percent; package, 20 percent; crib, 10 percent; and end piling, 37 percent. In total, 15.3 percent of the 1,347 boards measured were above 19 percent moisture content.

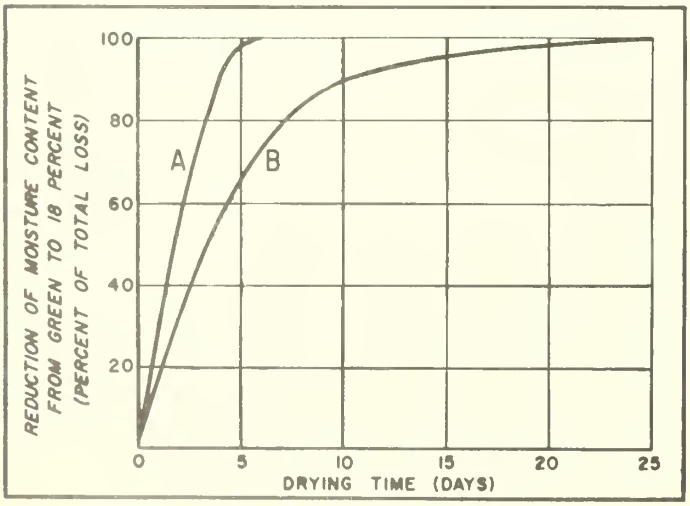

Figure 43.--Curve A represents the average of 4 predrying runs (forced air) at air velocities of approximately 200 to 1,000 feet per minute. Curve B is an average of 20 tests of air seasoning by 4 piling methods. Forced-air drying reduced moisture content as much in 6 days as air seasoning did in 25 days.

An interesting result of this study lies in the fact that the moisture content at lap joints in crib-piled lumber seems to increase with length of seasoning time, as shown in the accompanying tabulation. It is suspected that the presence of mold and decay fungi at these points increases the porosity of the wood, thereby increasing water absorption from rain.

Length of seasoning (Days)	Average moisture content at laps (Percent)
20	22.2
35	31.8
70	39.9

Development of Wooden Brick

In order to utilize lumber residue or low-grade material, tests are being made to determine the suitability of using this lumber for wooden brick to be used as room dividers (fig. 44), decorative partitions, or even exterior wainscoting on a house as shown in figure 45. Several joining methods excluding nailing are being tested for interior use. Some of the bricks used as exterior wainscoting were dipped in a commercial-type penta stain containing a water repellent. These exterior bricks are 1-3/4 x 1-3/4 x 12 inches in size and are nailed to each other and at intervals to the sheathing.

Double-Diffusion Treatment of Hardwood Fence Posts

The second annual inspection of the test fence posts treated by the double-diffusion process indicated that there were no failures among the treated posts. In this process, one water-soluble chemical is diffused into the wood, followed by like treatment with another chemical; thereupon, the two interact and form an insoluble preservative. Several treating schedules were used plus untreated controls of each species (table 14). The posts, representing 5 hardwood species and southern yellow pine, are located in a test area on the Whitehall Forestry School Forest, near Athens, Georgia.

Table 14.--Failure among untreated controls for double-diffusion post treating study

Species	Posts	Failures first year	Failures second year
	- - - -	Number	- - - -
White oak	50	0	3
Red oak	50	0	4
Yellow-poplar	50	5	25
Red gum	49	6	25
Hickory	50	0	11
Pine	50	23	7
Total	299	34	75

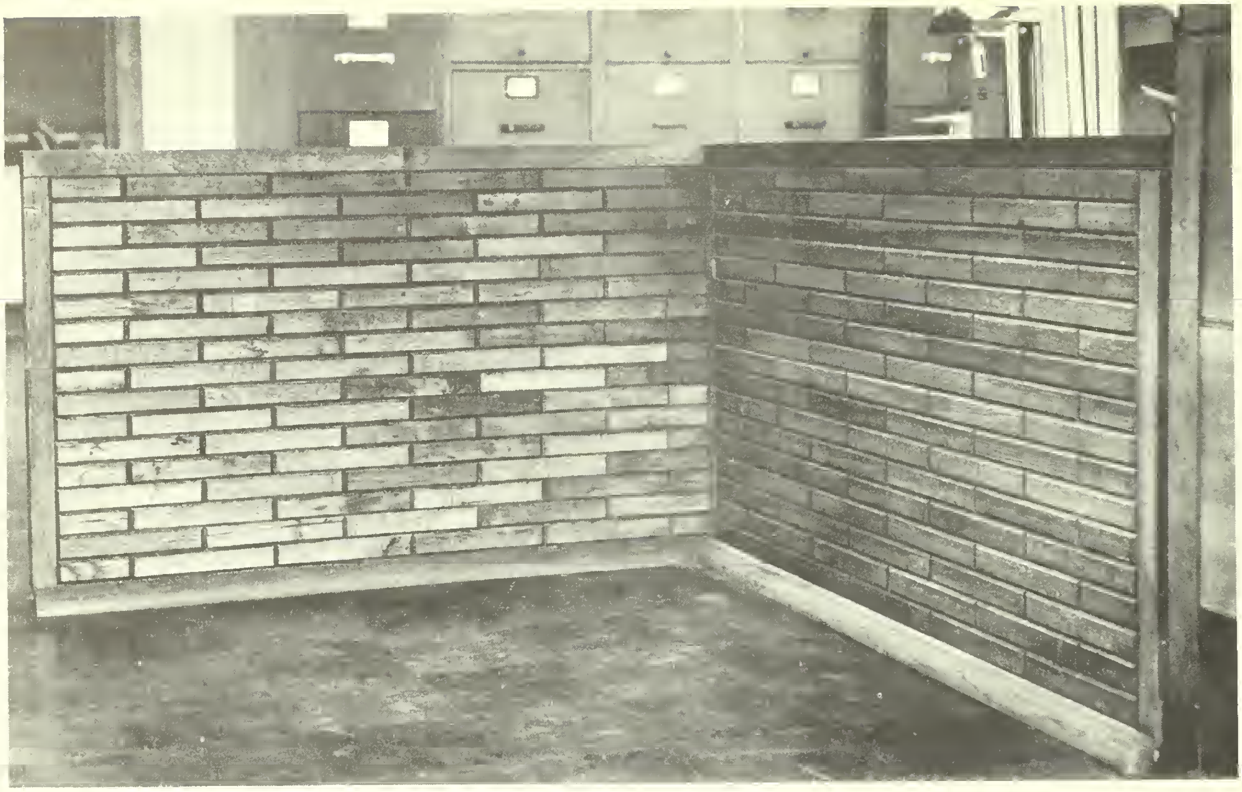

Figure 44.--Wooden brick stained walnut and used as room divider.

Figure 45.--Wall section to test wooden brick for use as exterior wainscoting. The brick can be multicolored, as shown, or uniform in color.

Factors Influencing Springback in Dry-Formed, Flat-Pressed Particle Board

In cooperation with North Carolina State College the characteristics of dry-formed, flat-pressed particle board are being investigated. Exploratory tests of the stability of the various layers (top face, core, and bottom face) of the particle board indicate that the core springs back (swells in thickness) less than the outer faces. Preliminary tests also indicate that there may be a minimum board density and a minimum resin content needed in order to achieve acceptable strength properties in a board. Boards made to a density of 40 pounds per cubic foot averaged approximately 20 to 30 pounds per square inch for strength in tension perpendicular to the face. However, boards made under the same condition, except that density was increased to 46 pounds per cubic foot, averaged 70 to 80 pounds per square inch. Future tests will be made at the 46-pound density.

Tension Wood in Hickory

During the felling and bucking of hickories some trees develop splits of varying degrees. These splits, of course, reduce the volume of lumber that can be cut from the logs. Because of the apparently unpredictable splitting behavior and because of the resultant loss, several studies have been made investigating various environmental and anatomical characteristics which might affect splitting. A relationship was found between tension wood present in a tree and the splitting characteristics. In considering this relationship, it became apparent that information was needed as to the relative amount of tension wood present in trees classified as splitters, nonsplitters, and leaners. A tree from each class was systematically and intensively sectioned. It was found that the highest percentage of gelatinous fibers occurred in a severe splitter; there was no significant relation between gelatinous fibers and radii or height above ground. Where no splitting of any serious degree was involved, but where tree lean was considered excessive, gelatinous fibers were found in greatest concentration on the upper side of the lean. In trees exhibiting little splitting and no apparent lean, the gelatinous fibers may occur rather sporadically and scattered throughout the tree.

Ninety-six percent of the total number of observed annual rings of the nonleaning splitter tree had gelatinous fibers present at all five sample distances above the ground. The leaning nonsplitter tree had a concentration of gelatinous fibers of 16 percent at stump height and 60 percent at 30 feet. The straight nonsplitter tree had only 2 percent concentration at stump height and 37 percent at 18 feet. The gelatinous fibers were generally found in the springwood for all conditions, but often continued into the summerwood.

Moisture Content of Wood in Use

A fundamental problem with wood products in use relates to the amount of moisture in the product and how much it will shrink and swell with changes in moisture conditions. Any wood product such as furniture will swell during wet weather so that drawers stick, and shrink during dry weather until parts become loose. These moisture content changes vary from locality to locality,

showing trends or ranges within, for example, the mountain area, the Piedmont, or Coastal Plain. Wood products to be used in any of these regions will be fabricated at a higher or lower moisture content to suit local conditions.

Knowing the range of atmospheric moisture content for different areas can be very helpful to forest product manufacturers. For instance, some custom cabinetmakers inquire from their prospective buyers whether the area where the furniture will be used is characteristically damp, as in Florida, or dry, as in New Mexico. They also ask whether the house is insulated, the type of heating system used, and whether or not the house has a basement. They ask these questions to determine the equilibrium moisture content of the piece in use. The equilibrium moisture content is defined as "the moisture content at which wood neither gains nor loses moisture when surrounded by air at a given relative humidity and temperature."

Current information available on moisture content of wood in use is based primarily on regional atmospheric conditions as established from weather records. Data of greater precision are needed if forest products are to perform satisfactorily in competition with other materials.

Several years ago, the California Dry Kiln Club set up a project to collect such data, which proved very successful and useful to kiln operators in that area. During a meeting of the Southeastern Dry Kiln Club in the early part of this year, the members expressed their desire to undertake a similar project and cooperate in the development of moisture-content data of wood. Basswood samples of predetermined moisture content and known oven-dry weight were distributed to members and placed in their homes with sample weighings taken once every week. Each member received three samples which were placed in prescribed locations within the home. By converting wood sample weights to moisture content, it was possible to determine moisture content for the wood samples for each of their weekly weighings. In this manner, variations from week to week and season to season have been calculated and plotted for the Coastal Plain, Piedmont, and mountains of the Southeast. Continuance of this work for perhaps another year will be necessary to determine prevailing moisture conditions in the areas under study. An illustration of variation in a home under study in the mountain region of Virginia is shown in figure 46. Notice that during the summer season the range in wood moisture content throughout the home is large, but when fall approaches and the heat is turned on,this range becomes much smaller.

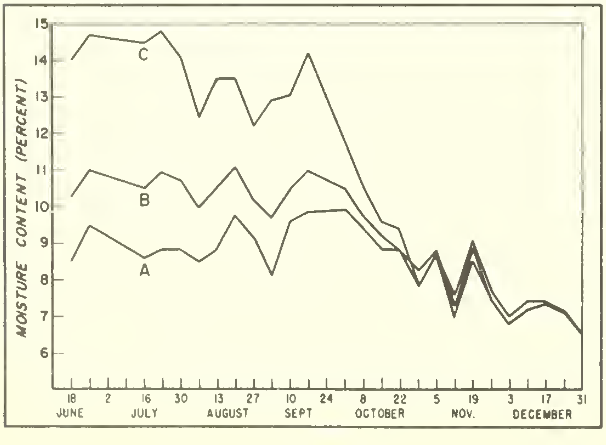

Figure 46.--Differences in wood moisture content between upstairs bedroom (A), downstairs bedroom (B), and basement (C) in a Virginia mountain home, June-December 1957.

WATERSHED MANAGEMENT

Interpreting Coweeta Water-Yield Results

Water use by forests and how man can control this is being studied in a series of watershed treatments at the Coweeta Hydrologic Laboratory, best illustrated by the total forest cut on Watershed 17.

The Emmenthal studies in Switzerland focused early attention on vegetation streamflow relations; and later in Colorado the Wagon Wheel Gap experiment measured some hydrologic effects of timber cutting, though mainly indicating need for more careful experimental control because of the many variables. As perhaps the third in this sequence of major investigations, the widely-known Coweeta experiment on Watershed 17 has demonstrated conclusively that under certain conditions, cutting all woody vegetation can increase water yields substantially without any attendant increase in stormflow or soil loss.

Perhaps no other Coweeta study has prompted such a variety of interpretations; and since these commonly reflect some misconceptions, a highlight review of the Watershed 17 experiment and its main findings may be helpful.

The purpose of the experiment as stated in the original plan was to study the effect on the water balance of cutting all trees, shrub cover, and regrowth from a 33-acre watershed as a gross measure of evapotranspiration. The experiment used two gaged watersheds, No. 17 and a control unit against which it was calibrated for 5 years before treatment. In the spring of 1941, all trees and shrubs were felled on No. 17 and the tops lopped and scattered. No roads were constructed nor were timber products removed. However, all sprouts and shrubs were cut back annually on Watershed 17 from 1942-1955 except for several of the war years.

The increased streamflow the first year--16 area inches of water--is attributed largely to reduced transpiration. It is evident, however, that there was a total interruption of transpiration only until the sprouts and herbaceous plants began to grow back the first summer. What is commonly overlooked is the lush growth of woody sprouts and herbaceous plants, with a considerable potential for water consumption, which has occupied most of Watershed 17 much of the time during the course of the experiment (fig. 47). Under such cover, evaporation from a forest floor insulated by the slash has probably not changed much; and interception losses of rainfall, though undoubtedly reduced, have not been eliminated.

It should be added, that in subsequent years when all regrowth was cut back annually, the net effect on streamflow was to maintain an increase of about 11 area inches per year over pretreatment flow. This means a yield of about 300,000 gallons per acre annually over that from undisturbed forest

cover--a highly useful increase from the point of view of a water user in that the greater yield came as a sustained, well-regulated flow, and not as storm runoff.

Figure 47.--A portion of clear-cut Coweeta Watershed 17 after all regrowth had been cut back each year for 18 years. Covering most of the watershed are sprouts of oak, black locust, yellow-poplar, and many other woody species. Sprout growth exceeds 6 feet in height each season.

Although valuable inferences can be drawn from this Coweeta experiment, the findings obviously do not afford a direct or complete measure of evapotranspiration losses but ratherof net streamflow after cutting had modified the hydrologic processes. A chief accomplishment has been to show in a carefully controlled experiment what can be accomplished in altering the water cycle in man's favor by drastic removal of dense vegetation from a site with deep soils and an exceptionally wet climate. Moreover, the results may represent the near-maximum influence man can expect to have on the water balance in a temperate zone, and hence the upper limits of increased and regulated flow that watershed managers can achieve by altering plant cover.

A notable point of interest to many is that the treatment has been sustained for nearly eighteen years without significant increases in either storm peak or stormflow frequency. Indeed, some visitors are inclined to interpret this as evidence that forest cover is not essential in protecting soils and controlling damaging runoff. On the contrary, the experiment documents very well the role of forests in creating optimum soil conditions for water intake and storage, stable enough in this instance to last for many years. Thus, for the most part, the soil on Watershed 17 remains essentially a forest soil, deeply channeled by decaying roots, permeated each year by the root systems of vigorous new growth, and receiving yearly a renewal of litter from leaf fall and cutting operations.

On the other hand there is slight though inconclusive evidence of the slow beginnings of watershed impairment from continual cutting. A comparison of plant growth on newly cutover land with that following the 12-year cut on Watershed 17 showed the same quantity of plant material, but on smaller stems in the twelfth year. However, it is suspected that the continued high production of litter is partly offset by more rapid oxidation of organic matter on Watershed 17, due to higher temperatures which prevail near the ground. Soil profile observations after the 12-year cut support this, because they show on the average about half as much unincorporated humus on the surface of Watershed 17 as on the adjacent control watershed. Although a comparison of the percent of water-stable aggregates in the upper layers of the two sites showed a slightly greater percentage in favor of the control, conditions for water intake and storage were highly favorable on both watersheds. Of more immediate significance perhaps is that plant composition on the shallow soils and exposed ridges representing about 10 percent of the watershed shows a gradual shift toward broomsedge and other plants indicative of lower fertility and ecologic deterioration (fig. 48).

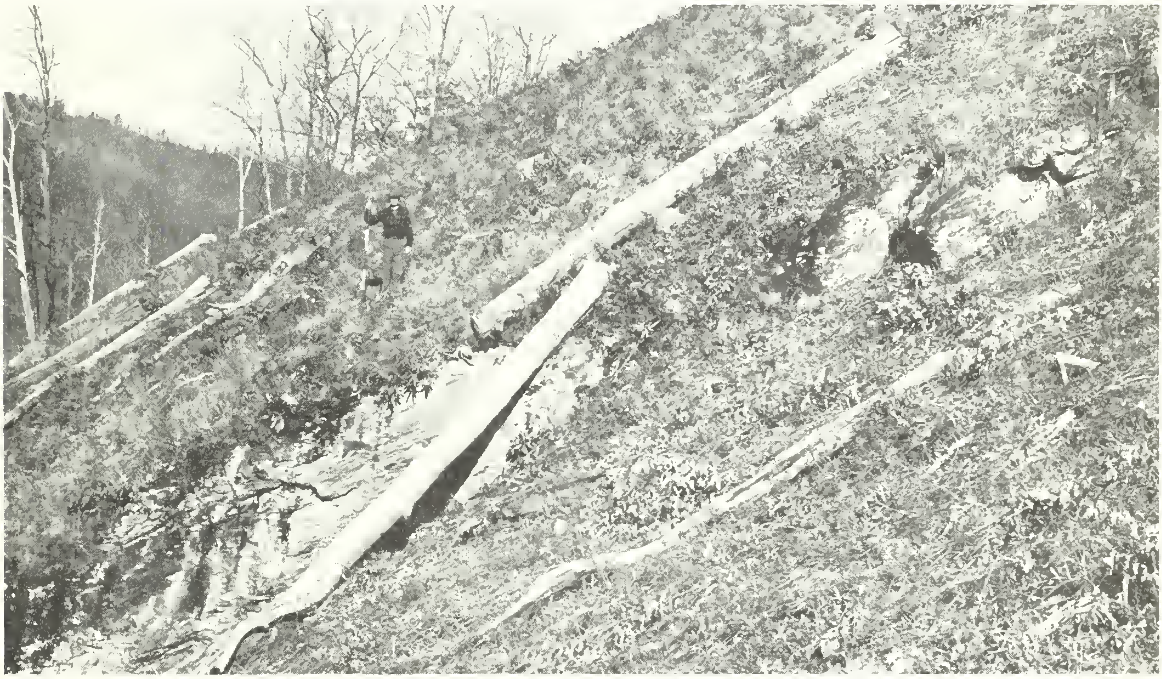

Figure 48.--Exposed ridge areas of relatively shallow soil on Watershed 17 are occupied mostly by broomsedge, laurel, and low oak sprouts after 18 years of brush cutting.

Such changes are as yet scarcely measurable and do not reflect any appreciable deterioration in soil conditions due to treatment. Nevertheless, the balance between stable watershed conditions and the beginnings of accelerated decline is always a delicate one; and for less favorable soils, climate, cover, and previous uses than obtain for Watershed 17, repeated clear cutting of this type doubtless can impair water quality, streamflow equilibrium, and the land itself. Thus, the time-honored idea that good forests and good forest soils mean good hydrologic conditions is in no sense undermined, and indeed seems well documented by this particular study.

Soil Biology in Rehabilitating Piedmont Soils

Leaves, twigs, and branches that fall on a lawn are often a nuisance, but in the forest this material is an extremely important component of the soil. Its contribution to soil-building has been the focus for much of the watershed management research effort in the Piedmont, where problems of rehabilitating poor land are paramount. Recently this work has led to exploratory studies of factors, particularly the soil fauna, contributing to decomposition of forest litter.

Forest litter forms a blanket and protects the mineral soil from raindrop splash and subsequent erosion. The material then decomposes and enriches and structurally modifies the soil as it mixed with the mineral particles. Some of the leaves may disintegrate and move down into the soil by gravity or in percolating water. Much of the litter is changed by living organisms, many so small they can't be seen unless magnified. The fungi and other plants invade and induce decay of the tissue, the bacteria attack it, and the soil animals feed upon it and pass it through their bodies. All of these things contribute to soil building and in some degree are at work no matter what the soil or what type of vegetation it supports.

Two contrasting soils with typical litter accumulations are shown in figure 49. One is beneath an old-growth stand of oak-hickory hardwood and is very rich in organic matter. Soon after the leaves fall in the autumn, they begin to disappear into the mineral soil. This produces a rich, porous surface soil that takes in water rapidly and supports good tree growth. The other photograph shows the sandy surface soil of a wornout old field now supporting a 20-year-old loblolly pine stand. This compact sand is very low in organic matter, and as the needles drop they mostly accumulate on the surface rather than becoming a part of the mineral soil. Obviously, these sites are quite different for many reasons, such as previous use of the land, the soil series, and the number of years since the land was farmed. But why have they developed in this manner and why have they become so extremely different?

Studies just begun in the Piedmont region of South Carolina show some interesting possibilities of introducing soil fauna on poor sites. Sampling a bare clay soil disclosed only 23 animals per square foot of soil in the surface 2 inches. A similar soil nearby was mulched with several inches of pine litter, and a year later there were 520 animals in a comparable volume of soil. However, the number of animals present apparently is not the whole story. The rich hardwood site shown in figure 49 had about 500 animals per square foot, while the old-field pine site had over 1,200. Presumably, the particular species of soil fauna are also important, since these vary in size, eating habits, and body chemistry. Some, such as the centipedes, are relatively large and feed on other animals, while the springtails, a small type of insect, eat only dead vegetation. Similarly, an earthworm producing many channels in the soil as it moves about hunting for food is perhaps more effective in humus formation and soil building than thousands of mites or small insects. But, little is known about this and other basic questions such as the feeding preferences of the various types of soil fauna that inhabit forest litter and help break it down.

Rebuilding or improving soil in the forest obviously must be done from the surface down. Once the litter drops from the tree, it begins to bring about changes in the soil. Through studies of the forest floor, soils, and faunal populations, we have a great deal to learn about these changes.

Figure 49.--Upper photo, loose, crumbly surface soil under an old-growth hardwood stand. This land has not been cropped in over a hundred years and is in top hydrologic condition. Lower photo, sandy soil of an old field in loblolly pine. This wornout Piedmont land was producing cotton until trees were planted about 20 years ago.

Chemical Spraying to Control Gallberry

Tests at the Alapaha Experimental Range in cooperation with the Georgia Coastal Plain Experiment Station and Agricultural Research Service are providing some good leads for controlling the undesirable shrub gallberry.

An earlier study showed that yearly burning killed back top growth but sprouts quickly took over and produced as many or more stems than before (fig. 50). Later tests using chemicals indicated that 2, 4, 5-T was superior to several other herbicides. Hence, a study was started in 1956 comparing foliage spray applications of the low-volatile ester at 2, 3, and 4 pounds of acid equivalent per acre, applied with oil and water and with and without preburning treatment.

Figure 50. --Gallberry resprouted vigorously on test plot areas on the Alapaha Experimental Range after burning, and is crowding out desirable forage grasses.

Survival of gallberry sprayed in May, August, and November 1956 was observed in October 1957 (table 15). Date of application and carrier proved important to spray effectiveness. November application with oil and August spraying with water gave best control, reducing gallberry stems 75 to 80 percent. Effectiveness was not appreciably influenced by rate of application, or by burning in March, about two months before the first spray application.

Table 15.--Effect of 2, 4, 5-T applications on gallberry, 1956 1/

Herbicide carrier	May	August	November	Average
	Percent survival 2/			
Water	61	24	118	67
Diesel oil	63	43	20	42
Average	62	33	69	

1/ Five percent LSD for carrier = 12.5; for date = 15.3; for interaction = 21.6.

2/ Observed number of live gallberry stems October 1957 expressed in percent of live stems in January 1956, prior to treatment.

Spread of gallberry and saw-palmetto throughout the piney woods country is of growing concern to land managers and merits much attention. Control is difficult, and interagency research efforts and further exploratory tests are needed.

Herbage Production from Freshly Burned Range in South Florida

Burning native ranges every two or three years to "freshen" herbage and remove the accumulated rough is a common practice of ranchers in south Florida, and is routine procedure in the grazing trials under way on the Caloosa Experimental Range in cooperation with the Babcock-Florida Company (fig. 51).

Figure 51.--Burning land on the Caloosa Experimental Range for herbage production study.

To obtain information on periodic growth and nutritive value following burning, herbage samples were clipped at six 2-week intervals on an ungrazed range that was burned in February 1957; and herbage analyses were made for the Caloosa project by the Georgia Coastal Plain Experiment Station and Agricultural Research Service.

Herbage production is shown in figure 52. Three weeks after the burn, when sampling was begun, total production averaged 65 pounds per acre (moisture-free), with pineland threeawn (Aristida stricta) making up 97 percent of this total. On May 30, fifteen weeks after burning, total production had increased to 927 pounds per acre, and pineland threeawn still contributed 79 percent to understory (grasses, grasslikes, and forbs) composition. Yellow-eyed grasses (Xyris spp.), other forbs, and umbrellagrass (Fuirena scirpoides) were the primary components of understory other than pineland threeawn.

Shrubs lagged behind recovery of understory. Seven weeks following burning, shrub production averaged only 4 pounds per acre. Shrub production was composed almost entirely of saw-palmetto, with only traces of Seminole tea paw paw (Asimina reticulata) and gopherapple (Chrysobalanus oblongifolius).

In general, the nutritive levels of understory herbage were greatest right after burning (fig. 53). Crude protein and phosphorus were highest, and lignin lowest in early samples.

Crude protein declined throughout the sampling period, becoming inadequate for cattle maintenance in about the eleventh week following burning.

Phosphorus in understory herbage declined from 0.14 percent initially to 0.04 percent on May 30. Thus, phosphorus, borderline for animal nutrition 3 weeks after burning, became very inadequate in later clippings. Calcium, hovering near 0.10 percent for 11 weeks following burning and then dropping to 0.07 percent on May 30, was at no time at an adequate level. Both calcium and phosphorus must be supplied yearlong as a supplement on south Florida native range to maintain beef cattle in good condition.

The first shrub samples were taken 9 weeks after burning when sufficient material became available. Shrubs consistently contained more phosphorus than did understory herbage, and had increased in calcium and crude protein at 13 and 15 weeks following burning. Phosphorus and crude protein remained fairly constant but at levels borderline for protein and deficient for phosphorus. Calcium increased to borderline levels in May. Lignin in understory herbage was consistently less than in shrubs, which suggests that the nutrients in shrubs may have been less available to the cattle.

Seeding Pasture Plants to Improve Southern Forest Range

Although vast acreages of cutover longleaf-slash pine forests in the Southeast are being reforested at a rapid rate, they can continue to produce large quantities of cheap forage as a byproduct in growing timber. Since the

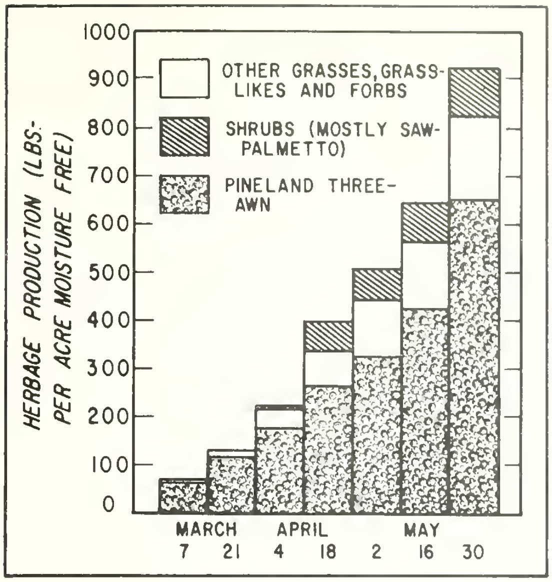

Figure 52. --Herbage production on a south Florida range after a burn on February 14, 1957.

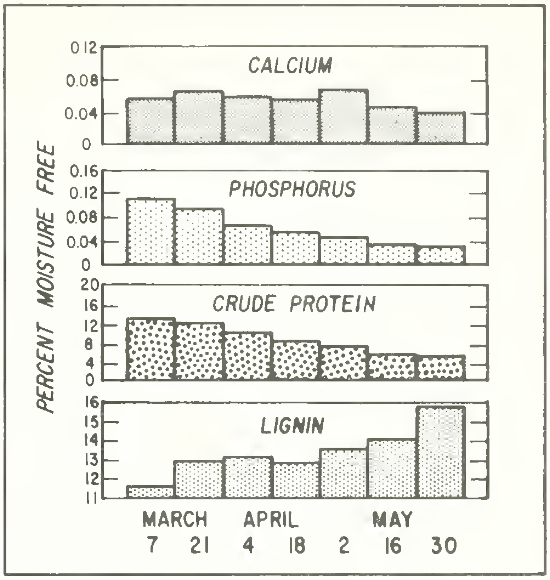

Figure 53. --Chemical composition of ungrazed herbage after a burn on February 14.

native forage species decline in quality and must be supplemented seasonally with other feed, the idea of replacing them with more nutritious tame forage plants has always had appeal and has prompted some research. Moreover, the trend in recent years toward extensive site preparation for tree planting, as well as increased use of fertilizer, should greatly enhance opportunities for introducing new forage plants on southern ranges.

Results of some cooperative seeding-fertilization trials in south Georgia point up some of the possibilities and problems in converting piney woods range to superior forage plants. A 5-year study, 1949-54, utilized some 40 acres of typical "flatwoods" land on the Alapaha Experimental Range. Seedlings of carpetgrass and common lespedeza were compared with those of another grass-legume combination (Dallisgrass and big trefoil), on burned and undisturbed, on chopped, and on disked soils. Choice of the two mixtures was prompted by earlier indications that these species were promising ones and that the carpetgrass-lespedeza combination could be successfully established with relatively small applications of fertilizer. Accordingly, annual fertilization was at the rate of 30 pounds of phosphate and 30 pounds of potash per acre on the carpetgrass-lespedeza units, and 60 pounds each on the Dallisgrass-trefoil plots.

Carpetgrass and lespedeza with no land preparation gave best results, and developed stands that maintained themselves throughout the 5-year study period. Lespedeza was not benefited by land preparation; but carpetgrass, which took over eventually on all units regardless of treatment and became the most abundant and important grass for grazing, established itself more quickly where the land was disk-harrowed (fig. 54). On the units of undisturbed sod, burning and close grazing enabled carpetgrass to spread quickly and develop good stands.

Figure 54.--Upper photo, bush-and-bog harrow destroyed native sod and eliminated most of shrubs on right. Area on left was undisturbed. Lower photo, five years later, very few shrubs or weeds were present on a good carpetgrass sod fertilized at a low rate. Native shrubs had increased in height and blackberry invaded area on left, which had been fertilized at moderate rate.

Dallisgrass was favored by land preparation but failed to establish itself on burned unbroken sod. However, where successful Dallisgrass stands were established, they were finally crowded out by native carpetgrass in a few years.

Big trefoil became well established with or without land preparation. While it sometimes furnished valuable feed during spring and summer, drought, disease, and insects heavily damaged the stands and made for exceedingly erratic production from year to year.

Native grasses decreased with grazing, and land preparation definitely eliminated most of them.

Shrubs remained reasonably stable where the land was not broken and the fertilizer applications were low, but blackberry spread greatly and took over on the moderately fertilized and the more moist areas. Moreover, other undesirables such as dogfennel and goldenrod also became troublesome on moderately fertilized units. Such shrub and weed invasions point up the difficulties when attempting to convert the piney woods to other forage types or to maintain the more desirable ones.

Calculations of costs and returns show that disking or brush chopping did not pay. Although weight gains of cattle were greatest with heavier fertilization, broadcasting carpetgrass and lespedeza on burned but otherwise undisturbed areas was the most economical practice, netting about $4 per acre per year in saleable beef over treatment costs.

Obviously, range improvement methods need more study if practical and profitable methods are to be developed to meet southern timber growers' requirements. A related need is for greater research efforts so that we can learn how to keep palmetto, gallberry, and other undesirable plants from taking over the piney woods.

PUBLICATIONS

by

MEMBERS OF THE STAFF, INCLUDING COOPERATORS

Calendar Year 1957

ANDERSON, W. C.
Sawtimber prices are highest in the fall. Southeast. Forest Expt. Sta. Res. Note 105.

(Seasonal price pattern for sawtimber stumpage in South Carolina.)

ANDERSON, W.C.
Some likely effects of closer utilization on the supply of southern stumpage. Soc. Amer. Foresters Proc. 1956: 130-132.

(Making the supply of timber go farther by closer utilization will affect stumpage prices.)

BARBER, J. C.
A vacuum sowing device for experimental nurseries. Jour. Forestry 55(12): 907.

(Device facilitates rapid sowing, with a precise count and spacing that permits germination estimates to be made from seedling counts.)

BARBER, J. C., and DORMAN, K. W.
Slash pine progeny tests indicate genetic variation in resistance to rust. Southeast. Forest Expt. Sta. Res. Note 104. Also in Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 44-46.

(Progeny groups of certain maternal parents had only about half as many infected trees as did other groups.)

BARBER, J. C., and STEWART, D. M.
Vacuum storage of pollen proves feasible. Minnesota Forestry Notes 62, 2 pp.

(Pollen of jack pine, white spruce, and Norway spruce can remain viable for at least one year when stored under vacuum with its coincident drying.)

BEAUFAIT, W. R., and NELSON, T. C.
Ring counts in second-growth baldcypress. Jour. Forestry 55(8): 588.

(Accurate ring counts can be made on increment cores of baldcypress by examining the sectioned cores under a magnification of 20 diameters.)

BENNETT, F. A.
Gum yield by diameter class and season for slash pines. Naval Stores Rev. 67(4): 8, 9. Also in AT-FA Jour. 19(10): 6-8.

(During a 16-week virgin working season in 17-year-old slash pine plantation the 13-inch trees yielded half again as much gum as 9-inch trees. The peak period for gum flow was in June.)

BOYCE, J. S., Jr.
Relation of precipitation to mat formation by the oak wilt fungus in North Carolina. Plant Dis. Rptr. 41(11): 948, 949.

(Mats were more abundant after a wet autumn than after a dry one.)

BOYCE, J. S., Jr.
Important tree diseases in the South. Sixth Ann. Forestry Symposium Proc. 1957: 123-129.

(Forest and nursery diseases and their control.)

BOYCE, J. S., Jr.
Oak wilt spread and damage in the Southern Appalachians. Jour. Forestry 55(7): 499-505.

(Oak wilt is spreading slowly, and damage is as yet negligible in North Carolina and Tennessee.)

BOYCE, J. S., Jr., and STEGALL, W. A., Jr.
Oak wilt in the Southern Appalachians. South. Lumberman 195(2441): 171, 172. Dec. 15.

(Wilt spread observed at 100 centers as well as in sample counties.)

BRENDER, E. V.
Loblolly pine not suited for bud pruning. Jour. Forestry 55(3): 214, 215.

(Bud-pruned trees grew slowly in both height and diameter, and had many epicormic branches.)

BRENDER, E. V.
Clear-cutting and planting loblolly pine in the lower piedmont. South. Lumberman 195 (2441): 188-190. Dec. 15.

(Satisfactory pine stocking can be obtained if hardwoods are controlled, particularly on the steep upper north and east slopes and all lower slopes.)

BRENDER, E. V., and HODGES, C. S.
Honeysuckle or trees? Southeast. Forest Expt. Sta. Res. Note 103.

(Some success in controlling honeysuckle has followed repeated sprays of butoxyl ethanol ester of 2, 4-D and 2, 4, 5-T 2:1 ratio, or 50 percent 3-amino-1, 2, 4-triazole wettable powder.)

BRENDER, E. V., and HODGES, C. S.
When drought strikes your pines. Forest Farmer XVI(12): 8, 9.

(Pine mortality and growth loss in Georgia were most severe on shallow soil having less than 16 inches of effective depth above an impervious layer.)

BRUCE, DAVID, and NELSON, R. M.
Use and effects of fire in Southern forests: abstracts of publications by the Southern and Southeastern Forest Experiment Stations, 1921-55. Fire Control Notes 18(2): 67-96.

BRYAN, M. B.
Forest statistics for the coastal plain of Virginia, 1956. Southeast. Forest Expt. Sta. Forest Survey Release 50, 42 pp., illus.

(Current statistics on forest area, timber volume, growth, and cut, with trends in forest area and timber volume.)

BRYAN, M. B.
Forest statistics for the piedmont of Virginia, 1957. Southeast. Forest Expt. Sta. Forest Survey Release 51, 52 pp., illus.

(Current statistics on forest area, timber volume, growth, and timber cut, with trends in forest area and timber volume.)

BYRAM, G. M.
Some principles of combustion and their significance in forest fire behavior. Fire Control Notes 18(2): 47-57.

(Discusses combustion chemistry, heat of combustion, heat transfer, combustion rate, and how they influence forest fire behavior.)

CAMPBELL, R. A.
Ten years of experimental farm woodland management in the Southern Appalachians. Southeast. Forest Expt. Sta. Paper 83, 11 pp., illus.

(Ten years of management show that a farmer would have received $3.55 per acre per year from stumpage sales. If he did the woods work, the returns would have been $10, and if he had done the loading and hauling, the total would have been $15.)

CAMPBELL, R. A.
Silvical characteristics of scarlet oak. Southeast. Forest Expt. Sta. Paper 86, 8 pp., illus.

(Extent and climate of the botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

CAMPBELL, W. A.
Opportunities, and challenge, of forest research. Forest Farmer 16(6): 10, 11, 27, 28.

(A strong cooperative approach toward forest research has been developed by the U. S. Forest Service, the State of Georgia, and the forest industries. But research funds are still only about 25¢ for every $100 of income from forest products.)

CLEMENTS, R. W.
New hammer tools for raising tins. Naval Stores Rev. 67(8): 10, 11. Also, with title New hammer tools for raising tins with double-headed nails, AT-FA Jour. 20(3): 4, 5.

(New hammer tools enable one to extract nails, raise tins, and attach the cup.)

CLEMENTS, R. W.
New spray puller for turpentining--how to use it. Southeast. Forest Expt. Sta. Paper 77, 15 pp., illus.

(Detailed instructions for the construction, maintenance, and use of an improved spray puller.)

CLEMENTS, R. W.
Southern lumber industry profiting from modern gum naval stores extraction methods. South. Lumberman 195(2441): 113, 114. Dec. 15.

(Modern extraction methods--bark chipping, acid-treatment, and removal of all hardware--are profitable for both the lumber and naval stores industries.)

COBB, F. W., Jr.
A test of the application of existing site-index curves to the flatwoods slash pine type. Southeast. Forest Expt. Sta. Res. Note 111.

(The slash pine site indices from U. S. Dept. of Agr. Misc. Pub. 50 were found to be 1 to 2 feet high for 15- to 30-year-old slash pine in northeast Florida and southeast Georgia.)

COBB, F. W., Jr.
Pitch streak--a disease of turpentined slash pine. Naval Stores Rev. 67(9): 4, 5.

(Incidence and severity of pitch streak increase in low vigor trees, on pond-margin sites, and in trees subjected to severe turpentining practices.)

COOPER, R. W.
Silvical characteristics of slash pine. Southeast. Forest Expt. Sta. Paper 81, 13 pp., illus.

(Extent and climate of the botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

COOPER, R. W.
Silvical characteristics of sand pine. Southeast. Forest Expt. Sta. Paper 82, 8 pp., illus.

(Extent and climate of the botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

DILS, R. E.
A guide to the Coweeta Hydrologic Laboratory. Southeast. Forest Expt. Sta., 40 pp., illus.

(Installations, program, and some results of 23 years of watershed research.)

DOOLITTLE, W. T.
Site index of scarlet and black oak in relation to Southern Appalachian soil and topography. Forest Sci. 3(2): 114-124.

(In the correlation of soil and topography with site index, the significant variables were depth of A horizon, position on slope, and percent of sand in the A horizon.)

DOOLITTLE, W. T.
Wear on soil mixer paddles and effect on mechanical analysis. Soil Sci. Soc. Proc. 1957: 662.

(Soil mixer paddles used in making mechanical analysis by the Bouyoucos hydrometer method should be replaced periodically to avoid errors in soil separates.)

DORMAN, K. W.
Breeding better pines. The Southern Planter 118(11): 20.

(Describes progress of cooperative research program in the South for breeding better forest trees.)

FOSTER, A. A., and HARRISON, R. P.
Seedling losses in Arizona cypress. Tree Planters' Notes 29: 20, 21.

(Phomopsis blight and the lesser cornstalk borer cause losses that can be reduced by spraying.)

GREENE, J. T., DORMAN, K. W., and BAUER, E.
Differential growth rate of young progeny of individual slash pine trees. Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 47-50.

(Demonstrates growth differences in progeny of different mother trees and indicates that the relationship between seed size and seedling growth is not strong when seed is kept separate by maternal parent.)

HALLS, L. K.
Grazing capacity of wiregrass-pine ranges of Georgia. Jour. Range Mangt. 10(1): 1-5.

(Nine acres of burned wiregrass range yielding 1,100 pounds of grass per acre provide ample feed for a 500-pound steer from March to January.)

HALLS, L. K., KNOX, F. E., and LAZAR, V. A.
Common browse plants of the Georgia Coastal Plain, their chemical composition and contribution to cattle diet. Southeast. Forest Expt. Sta. Paper 75, 18 pp., illus.

(Fourteen browse species contributed 16 percent of the total cattle diet in winter and spring, 8 percent in summer and 4 percent in fall. Saw-palmetto supplied large amounts of copper. Black gum and summersweet clethra were exceptionally high in cobalt.)

HALLS, L. K., BURTON, G. W., and SOUTHWELL, B. L.
Some results of seeding and fertilization to improve southern forest ranges. Southeast. Forest Expt. Sta. Paper 78, 26 pp., illus.

(Carpetgrass and common lespedeza seeded on undisturbed sod produced better stands and proved more economical than Dallisgrass or big trefoil. Land preparation tended to eliminate native grasses.)

HALLS, L. K., and SOUTHWELL, B. L.
Supplemental feeding of range cattle in wiregrass pine ranges of Georgia. Soc. Amer. Foresters Proc. 1956: 58-61.

(Maximum beef production on wiregrass range was contingent upon high levels of maintenance during the critical fall-winter periods.)

HANEY, G. P.
Seed production of shortleaf pine in the piedmont. Southeast. Forest Expt. Sta. Res. Note 113.

(Seed production records for eight stands of shortleaf pine in the Piedmont of North Carolina, South Carolina, and Georgia for 1954, 1955, and 1956.)

HARGREAVES, L. A., Jr., and DORMAN, K. W.
Administrative and technical aspects of establishing pine seed orchards. Soc. Amer. Foresters Proc. 1956: 92, 93.

(Summarizes the procedures and costs of establishing three seed orchards in Georgia, and suggests economical methods to be followed.)

HENRY, B. W., and HEPTING, G. H.
Pest occurrences in 35 of the southwide pine seed source study plantations during the first three years. South. and Southeast. Forest Expt. Stations, 7 pp., illus.

(Fusiform rust was building up rapidly in many loblolly and slash plantings. Tip moth was general in loblolly and shortleaf. Brown spot was common but under control on longleaf.)

HEPTING, G. H.
Are we winning the fight against tree diseases? Forest Farmer XVII(2): 4, 5, 14.

(The fight against tree diseases is slowly but gradually being won.)

HEPTING, G. H.
Diseases of the forest. Forest Farmer Manual, Ed. 5, pp. 10, 11.

(Describes success in controlling diseases and cites problems yet to be solved.)

HEWLETT, J. D., and ROSSOLL, HARRY
Coweeta Hydrologic Laboratory. Southeast. Forest Expt. Sta., 8 pp., illus.

(Pictorial booklet printed by Regional Office, Forest Service, USDA, Atlanta, Ga., shows important Coweeta installations and experiments.)

HILMON, J. B.
Do your cows get enough mineral on native range? Fla. Cattleman and Livestock Jour. 22(1): 69, 78.

(Cattle on unburned south Florida range need more supplemental mineral than cattle that have freshly-burned range.)

HODGES, C. S., Jr.
The occurrence of black root rot in some southern pine nurseries. (Abs.) Fifty-fourth Ann. Conv. Assoc. South. Agr. Workers Proc. 1957: 221, 222.

(Typical black root rot symptoms were found in 4 out of 16 southern pine nurseries in 1956.)

HOEKSTRA, P. E.
Stimulation of flower and seed production in slash pine. Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 74, 75.

(Root pruning, partial girdling, and fertilization induced 6-year-old saplings to flower. The high nitrogen content of a 7-7-7 fertilizer was more effective than the high phosphorus content of a 3-18-6 fertilizer.)

HOEKSTRA, P. E.
Air-layering of slash pine. Forest Sci. 3(4): 344-349.

(Air-layering in July gave better results than in September. Increased rooting followed an increase from 0.4 to 0.8 to 1.2 percent concentration of indolebutyric acid. A 1.2-percent concentration of napthalene acetic acid was not effective.)

HOEKSTRA, P. E.
A case study of species comparison on flatwoods soil. South. Lumberman 195(2441): 158, 159. Dec. 15.

(Slash pine gave the best over-all performance, although longleaf had the best survival and loblolly had the best growth despite tipmoth damage.)

HOEKSTRA, P. E., and JOHANSEN, R. W.
Growth of planted slash pine air-layers. Jour. Forestry 55(2): 146.

(Air-layers from 6-year-old saplings grew three and one-half times as much as did air-layers from 23-year-old trees during the first year after outplanting.)

HOEKSTRA, P. E., and MERGEN, FRANCOIS
Experimental induction of female flowers on young slash pine. Jour. Forestry 55(11): 827-831.

(On 7-year-old trees, root pruning, partial girdling, strangulation, and application of 5 pounds of 3-12-6 fertilizer per tree increased the number of trees bearing female flowers. On 21-year-old trees partial girdling, 20 pounds of 7-7-7 fertilizer, and 40 pounds of 3-18-6 fertilizer were effective.)

HUGHES, R. H.
Cane response to burning in the North Carolina Coastal Plain. N. C. Agr. Expt. Sta. Bul. 402, 24 pp., illus.

(Carefully controlled fire serves a useful purpose for renovating decadent cane stands and those weakened by grazing but will not improve range where most of the cane has been killed out or dominated by tree overstory.)

JOHANSEN, R. W.
What we know about air layering. Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 126-131.

(Summarizes experiences in air-layering, with particular reference to the effects of tree age and use of growth regulators on slash, loblolly, and shortleaf pine.)

KEETCH, J. J.
Occurrence rate as a measure of success in fire prevention. Fire Control Notes 18(1): 41-45.

(Graphs show use of relation between Burning Index and fire occurrence to measure effectiveness of fire prevention in a district, state, or region.)

KEETCH, J. J., and GLADSTONE, M. C.
1956 forest fires and fire danger in Connecticut, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.

(Thirteen separate state reports containing tables and graphs analyzing forest fires and fire danger.)

KLAWITTER, R. W.
Most cankered trees are good risks in loblolly pine sawtimber stands. Southeast. Forest Expt. Sta. Res. Note 107.

(Confirms the rule-of-thumb that cankered trees can be left for at least 5 years if any sound callus can be seen extending past both edges of the canker when the marker faces that side of the tree.)

KOVNER, J. L.
Evapotranspiration and water yields following forest cutting and natural regrowth. Soc. Amer. Foresters Proc. 1956: 106-110, illus.

(Increase was about 14 inches the first year, and 5.78 the twelfth, when basal area was about half that of original stand.)

KOWAL, R. J.
How to prevent insect damage to wood structures. Forest Prod. Jour. VII(3): 29A-32A, illus.

(Control methods are described for subterranean termites, drywood termites, and powder-post beetles.)

KOWAL, R. J.
Increasing importance of insects in forest management in the South. Va. Tech. Forester v. IX: 19-22, illus.

(Problems and control methods are reviewed.)

KOWAL, R. J.
Index to your cooperating agencies. Pest Control Magazine 25(12): 9, 10, 36.

(The work of public agencies, particularly research, and how it contributes to the performance of the pest control profession.)

KOWAL, R. J.
Insects commonly attacking forest trees and products in the South. Forest Farmer Manual, Ed. 5, pp. 30-36.

(Short discussion of forest entomology in the South with tabulated information on identification, life history, damage and control of forest insects.)

KOWAL, R. J.
Progress in southern forestry--Forest Insects. Forest Farmer Manual, Ed. 5, p. 10.

(Rapid studies are being made in improving the detection and suppression of insect outbreaks and in developing methods of control.)

KOWAL, R. J.
Relation of forest management to the forest insect problem in the South. Soc. Amer. Foresters Proc. 1956: 175-180.

(Insect problems in the South and their control, with emphasis on control by good management practices.)

KOWAL, R. J.
We can check the silent killers. Forest Farmer XVII(3): 6, 7, 12, 18.

(Important insects, methods of control and needs for improving detection and prevention of insect outbreaks.)

LANGDON, O. G.
The first successful direct seeding in south Florida. South. Lumberman 195(2441): 180, 181. Dec. 15.

(Repellent-treated slash pine seed sown at $\frac{1}{2}$, $1\frac{1}{2}$, and $2\frac{1}{2}$ pounds per acre produced 810, 3,200, and 5,400 seedlings per acre. Chopping with a Marden brushcutter before sowing had little effect on number of seedlings.)

LARSON, P. R.
Effect of environment on the percentage of summerwood and specific gravity of slash pine. Yale Univ., School Forestry Bul. 63, 89 pp., illus.

(Percentage of summerwood is the best single criterion for estimating specific gravity. Within a tree cross-section,percentage of summerwood is largely controlled by age. Between locations the best estimate of summerwood percentage was June + July rainfall in combination with depth to a fine textured horizon.)

LARSON, R. W.
How long does it take to grow pine pulpwood or sawtimber in North Carolina? Southeast. Forest Expt. Sta. Res. Note 106.

(Average tree diameter plotted over age by site index for natural stands.)

LARSON, R. W.
North Carolina's timber supply, 1955. Southeast. Forest Expt. Sta. Forest Survey Release 49, 71 pp., illus.

(Forest area, timber volume, growth, and timber-cut statistics; also trends in forest area and timber volume.)

LARSON, R. W.
The timber supply situation in Georgia. U. S. Dept. Agr. Forest Resource Report 12, 51 pp., illus.

(Timber supply in relation to current and future needs of wood-using industries.)

LOTTI, THOMAS
An effective control for cull hardwoods. Southeast. Forest Expt. Sta. Res. Note 108.

(Spring application of one part 2, 4, 5-T in 20 parts of fuel oil in frills was effective on all species tested except American holly.)

LOTTI, THOMAS
Silvical characteristics of cherrybark oak. Southeast. Forest Expt. Sta. Paper 88, 9 pp., illus.

(Extent and climate of the botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

LOTTI, THOMAS, and KLAWITTER, R. A.
Let nature plant her share. Forest Farmer XVII(1): 12, 13.

(Planting is not needed on areas with loblolly seed trees if hardwoods are controlled by fire, disking, or chemicals. A good treatment combination for the coastal plain is prescribed fire followed by disking prior to seedfall and logging.)

LOTTI, THOMAS, and SHIPMAN, R. D.
Return of longleaf to the sandhills. Forest Farmer XVI(4): 12, 14, 15.

(Longleaf pine can be successfully planted in the Carolina-Georgia Sandhills when grades 1 and 2 stock are planted on cleared, plowed, and dragged scrub oak sites or on furrowed old fields.)

LUXFORD, R. F., and SMITH, W. R.
Observations of damage to houses by high winds, waves, and floods and some construction precautions. U. S. Forest Serv., Forest Prod. Lab. Rpt. No. 2095, 26 pp., illus.

(Discusses failure of various types of construction and illustrates proper methods.)

McALPINE, R. G.
Age of tree and root development by air-layers in loblolly pine. Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 59-63.

(Rooting was best in the youngest trees, and decreased sharply with increasing age. All living air-layers on 2-year-old trees rooted, but none rooted in trees 17 years old or older.)

McALPINE, R. G.
Gibberellic acid, a potential growth regulator for forest trees. South. Lumberman 195(2441): 172, 173. Dec. 15.

(Gibberellic acid has not been used extensively with forest trees; usually the hardwoods have shown more response than have the conifers.)

McCAMBRIDGE, W. F., and KOWAL, R. J.
Forest insect conditions in the Southeast during 1956. Southeast. Forest Expt. Sta. Paper 76, 7 pp., illus.

(Discussion of survey and control activities.)

McCAMBRIDGE, W. F., and ROSSOLL, HARRY
Recommended procedures for control of the southern pine beetle. Southeast. Forest Expt. Sta., 12 pp., illus.

(Illustrated handbook for field crews and supervisory personnel. Outlines steps in planning as well as control.)

McCORMACK, J. F.
Spectacular rise in southern pulpwood production continues. Southeast. Forest Expt. Sta. Res. Note 109.

(Production of round pulpwood and chips from plant residues in 1956 by state.)

McGREGOR, W. H. D.
Fertilizer increases growth rate of slash pine. Southeast. Forest Expt. Sta. Res. Note 101.

(Fertilizer applied in March, June, and August for 4 years at an annual rate of 500 pounds per acre increased the gum yields by 23 percent and the growth by 36.6 percent.)

McGREGOR, W. H. D., and KRAMER, P. J.
Effect of photoperiod on photosynthesis, respiration, and growth of loblolly pine seedlings from two sources. (Abs.) Plant Physiol. 32: 10, 11.

(The higher photosynthesis rates of larger seedlings are a result of greater needle area. Longer photoperiods increase the needle area, but do not alter the basic rate of photosynthesis.)

McLINTOCK, T. F.
Research--organization and program at Lake City. Forestry Club, Univ. Fla., Slash Pine Cache v. XVI.

(Major fields of work are in forest management, naval stores, range management, genetics, and forest insects.)

MERKEL, E. P.
Forest entomology in the South--past, present, and future. Fla. Ent. 40(4): 119-122.

(Development and progress in research since 1890.)

MERRICK, E. T.
It pays to listen. American Forests 63(4): 30, 31, 51, 53, 54.

(Manager of Florida furniture plant says modernization and quality control advised by Forest Utilization technicians bring good results.)

NELSON, T. C.
Early responses of some southern tree species to gibberellic acid. Jour. Forestry 55(7): 518-520.

(Gibberellic acid increased the height growth of eastern cottonwood, sycamore, yellow-poplar, sweetgum, cherrybark oak, willow oak, and southern red oak from 75 to 353 percent. The response was less clearcut for white oak and white pine. Arizona cypress and water oak did not show any consistent increase.)

NELSON, T. C.
A method for vegetatively propagating yellow-poplar. Jour. Forestry 55(8): 589.

(Entire yellow-poplar seedlings were split longitudinally, the exposed tissues coated with lanolin, and the upper half of the stem clipped off. All seedlings so treated in December and January calloused over and grew.)

NELSON, T. C.
The original forests of the Georgia piedmont. Ecol. 38(3): 390-397.

(The original forests were estimated to be about 15 percent pine on the granitic lands, about 45 percent mixed pine-hardwoods on the gray, sandy lands, 35 to 40 percent hardwoods on the red lands, and perhaps 2 or 3 percent blackjack oak in the flatwoods.)

NELSON, T. C.
Rooting and air-layering some southern hardwoods. Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 51-54.

(Successful rooting of cuttings from eastern cottonwood, sycamore, and yellow-poplar, and successful air-layering of sycamore, green ash, sweetgum, and eastern cottonwood are reported.)

NELSON, T. C.
Survival and early growth of an eastern cottonwood plantation on the Piedmont. Tree Planters' Notes 28: 9.

(Unrooted cuttings planted in a disk-harrowed overflow bottom in January showed 88 percent first-year survival. Average height growth was 7 feet.)

NELSON, T. C., and BEAUFAIT, W. R.
Studies in site evaluation for southern hardwoods. Soc. Amer. Foresters Proc. 1956: 67-70.

(Discusses two approaches in site evaluation studies: the comparative site index method for a number of species and the soil-site relationships of individual species.)

NELSON, T. C., and MARTINDALE, D. L.
Rooting American sycamore cuttings. Jour. Forestry 55(7): 532.

(Cuttings 20 inches long from 1-year-old sprouts were made in October, kept in cold storage, and planted in November and in March. Survival and growth were best for large-diameter cuttings.)

NELSON, T. C., ROSS, R. D., and WALKER, G. D.
The extent of moist sites in the Georgia piedmont and their forest associations. Southeast. Forest Expt. Sta. Res. Note 102.

(Describes the species composition, physiographic sites, and relative extent of the cove and bottomland associations in the Georgia Piedmont.)

OLSON, D. F., Jr.
Planting walnuts and acorns on the farm. Furniture, Plywood and Veneer Council of the N. C. Forestry Assoc., Inc. Report No. 4, 4 pp.

(Collection, treatment, winter storage, and planting techniques.)

OSGOOD, E. A., Jr.
A bibliography on the southern pine beetle. Southeast. Forest Expt. Sta. Paper 80, 19 pp.

(References from 1890 through 1956.)

OSTROM, C. E., TRUE, R. P., and SCHOPMEYER, C. S.
Evidence on the mechanism of oleoresin flow as affected by chemical treatment of wounds. (Abs.) Plant Physiol. 32 (Supplement): 39, 40.

(Evidence suggests that sulphuric acid treatment does not increase the rate of oleoresin synthesis but serves chiefly to facilitate the flow of oleoresin from the resin ducts.)

PAGE, R. H.
Charcoal production in Georgia. Forest Utilization Service Release No. 7.

(Economics of charcoal production and information on raw material, yields, cost of equipment, screening and packaging, and marketing.)

PAGE, R. H.
Circular versus sash-gang mills. Forest Utilization Service Release No. 8.

(Comparison covers daily output, labor requirements, production per man-day, and overrun.)

PAGE, R. H.
Georgia sawmills convert coarse pine waste to salable wood chips. Forest Utilization Service Release No. 9.

(Status of debarking and chipping equipment; also equipment cost and chip yields.)

PAGE, R. H.
The occurrence and control of bluestain in lumber. Forest Utilization Service Release No. 10.

(Monetary losses from bluestain and control of bluestain, with a partial list of products effective in preventing stain, molds, and decay.)

PAGE, R. H.
Protection of lumber with stack covers while air-drying. Forest Utilization Service Release No. 12.

(Lumber stacks with sun- and rain-tight roofs, the construction of such covers, and the experience of a middle Georgia concentration yard operator.)

PAGE, R. H.
A natural exterior finish that is durable and attractive. Forest Utilization Service Release No. 13.

(Formula and directions for mixing.)

PAGE, R. H.
Glues and their use in the wood industry. Forest Utilization Service Release No. 15.

(A brief history of glues and their origin.)

PAGE, R. H.
Glues and their use in the wood industry. Forest Utilization Service Release No. 16.

(Properties and uses of the more important wood-working glues.)

PAGE, R. H.
Wood preservation in home construction. Forest Utilization Service Release No. 17.

(Results of a survey of preservatives and treated and untreated houses.)

PAGE, R. H.
Wood preservation in home construction. Forest Utilization Service Release No. 18.

(Methods of treating wood, and relative effectiveness of each method.)

PAGE, R. H., and CARTER, R. M.
Heavy losses in air seasoning Georgia pine and how to reduce them. Southeast. Forest Expt. Sta. Paper 85, 20 pp., illus.

(Data collected at 20 air-seasoning yards show seasoning losses by various causes and by four methods of stacking 4/4 lumber.)

PAGE, R. H., and HERRICK, D. E.
A guide-line light over the log deck can increase sawmill profit. Forest Utilization Service Release No. 14.

(Describes setup and advantages.)

PECHANEC, J. F.
The history and accomplishments of our Range Society. Jour. Range Mangt. 10(4): 189-193.

(Brief history of the American Society of Range Management from its formation in 1946 to its 10th anniversary in January 1957.)

PETER, RALPH
This business of charcoaling. Forest Farmer XVI(8): 12, 17.

(Types of charcoal kilns, research developments in charcoaling, and some economic factors to be considered.)

PETER, RALPH, and PAGE, R. H.
Interior paneling from low-grade oak. Forest Utilization Service Release No. 11.

(Utilization of low-grade lumber for interior paneling.)

QUINN, G. M., and BENGTSON, G. W.
Gum yield tables for intensively worked slash and longleaf pines. AT-FA Jour. 19(12): 4, 5. Also in Naval Stores Rev. 67(5): 6, 7.

(In overstocked stands, trees 8 inches and smaller in diameter yielded less than 200 barrels of gum per crop. Presents gum-yield tables by diameter and by crown-length percentage.)

ROTH, E. R., and COPELAND, O. L.
Uptake of nitrogen and calcium by fertilized shortleaf pine. Jour. Forestry 55(4): 281-284.

(Nitrogen absorption increased the growth and improved the foliage of littleleaf-diseased pines.)

RUMMELL, R. S.
Beef cattle production and range practices in south Florida. Jour. Range Mangt. 10(2): 71-78, illus.

(Discusses problems of south Florida's 10 million acres of native range and million head of beef cattle.)

SHIPMAN, R. D., and HATCHER, J. B.
Planting small slash pine seedlings. Forest Farmer XVI(5): 7, 18.

(Growth and survival in the South Carolina sandhills was best when slash pine seedlings are planted deep with only the bud exposed.)

SHIPMAN, R. D., and SCOTT, H. R.
Chemical control of small-diameter scrub oak. South. Lumberman 194(2422): 64, 65. Mar. 1.

(Turkey oak can be killed by basal and stump sprays of 2, 4, 5-T and by Ammate in cups or notches. The 2, 4, 5-T was least effective in winter and the Ammate in fall.)

SMITH, R. H.
Habits of attack by the black turpentine beetle on slash and longleaf pine in north Florida. Jour. Econ. Ent. 50(3): 241-244, illus.

(A detailed summary based on intensive research.)

SMITH, R. H., and LEE, R. E.
Black Turpentine Beetle. U. S. Dept. Agr. Forest Pest Leaflet 12, 7 pp.

(Life history and control methods.)

SMITH, W. R.
New developments in the veneer and plywood industry in the south. Soc. Amer. Foresters Proc. 1956: 155-158.

(Describes paperfaced veneer and plywood, impreg for diestock, etc.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Annual report for 1956. 99 pp., illus.

(Highlights of the Station's research results.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Southeast. Forest Insect and Disease Newsletter No. 3. 4 pp.

(Insect and disease conditions from the fall of 1956 to July 1957.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Southeast. Forest Insect and Disease Newsletter No. 4. 4 pp.

(Insect and disease conditions during the summer of 1957.)

STOREY, T. G.
A fuel-moisture stick wicket of new design for use at open-type fire danger stations. Fire Control Notes 18(2): 58.

(Illustrations and specifications of a device for supporting fuel-moisture sticks.)

TODD, A. S., Jr., and ANDERSON, W. C.
An appraisal of methods for salvaging small-sawmill residues in the Southeast. Southeast. Forest Expt. Sta. Paper 84, 37 pp., illus.

(A system of cost analysis useful in determining the cheapest method of salvaging pulp chips from slabs and edgings at portable sawmills.)

VIMMERSTEDT, J. P.
Estimating d.b.h. from stump diameter in Southern Appalachian species. Southeast. Forest Expt. Sta. Res. Note 110.

(Curves were developed to estimate diameter breast high, outside bark from both inside bark and outside bark measurements taken 6 inches above ground for nine species and species groups.)

VIMMERSTEDT, J. P.
Silvical characteristics of flowering dogwood. Southeast. Forest Expt. Sta. Paper 87, 11 pp., illus.

(Extent and climate of the botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

WENGER, K. F.
Annual variation in the seed crops of loblolly pine. Jour. Forestry 55(8): 567-569.

(Seed production varied inversely with seed crop and directly with May-to-July rainfall of the second preceding year.)

WHELAN, D. E.
Effects of land use on streamflow. Jour. Ala. Acad. Sci. 29(IV): 55-60.

(Theories of infiltration, runoff, ground water flow, and evapotranspiration in relation to land use and vegetation.)

WITHEROW, B. M., and SMITH, W. R.
Cost of operation for three types of charcoal kilns. Southeast. Forest Expt. Sta. Paper 79, 16 pp., illus.

(Operating costs and yields from $\frac{1}{2}$, $1\frac{1}{2}$, and 2-cord charcoal kilns; also temperature patterns developed during burns.)

WOODS, F. W., COPELAND, O. L., Jr., and OSTROM, C. E.
Soil management for forest trees. U. S. Dept. Agr. Yearbook 1957: 710-715.

(Illustrates forestry uses of irrigation, drainage, and fertilization, and the relation of soil moisture, structure, fertility, and past abuse of soil to forest growth, diseases, and species adaptability.)

ZAK, BRATISLAV
Littleleaf of pine. U. S. Dept. Agr. Forest Pest Leaflet 20, 4 pp., illus.

(Disease results from destruction of growing tips of roots by the soil fungus Phytophthora cinnamomi. Effects can be ameliorated by cutting practices. Sites can be rated for littleleaf hazard.)

ZAK, BRATISLAV
Resistance to littleleaf in shortleaf pine. Fourth South. Conf. on Forest Tree Improvement Proc. 1957: 41-43.

(Shortleaf pines on severe littleleaf sites are propagated by seeds and grafts for tests of resistance to Phytophthora cinnamomi.)

ZAK, BRATISLAV, and McALPINE, R. G.
Rooting of shortleaf and slash pine needle bundles. Southeast. Forest Expt. Sta. Res. Note 112.

(Needle bundles treated with indolebutyric acid were rooted in a 50-50 mixture of sand and peat moss.)

Southeastern Forest Experiment Station

Annual Report 1958

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Southeastern Forest Experiment Station
Asheville, North Carolina

Joseph. F. Pechanec,
Director

DIVISIONS AND CENTERS

SOUTHEASTERN FOREST EXPERIMENT STATION

December 31, 1958

Research Divisions	Officer in Charge
Forest Management	Walter M. Zillgitt
Station Management	George B. P. Mullin
Forest Economics	James F. McCormack
Watershed Management	H. Glenn Meginnis
Forest Fire	Karl W. McNasser
Forest Utilization	Walton R. Smith
Range Management	H. Glenn Meginnis
Forest Diseases	George H. Hepting
Forest Insects	R. Joseph Kowal

Principal Field Centers	Officer in Charge
Asheville Research Center, Asheville, N. C.	Robert A. Campbell
Athens-Macon Research Center, Athens, Ga.	William A. Campbell
Charleston Research Center, Charleston, S. C.	Thomas Lotti
Cordele Research Center, Cordele, Ga.	Norman R. Hawley
Coweeta Hydrologic Laboratory, Franklin, N. C.	Donald E. Whelan
Franklin Research Center, Franklin, Va.	George F. Gruschow
Lake City Research Center, Lake City, Fla.	Karl F. Wenger
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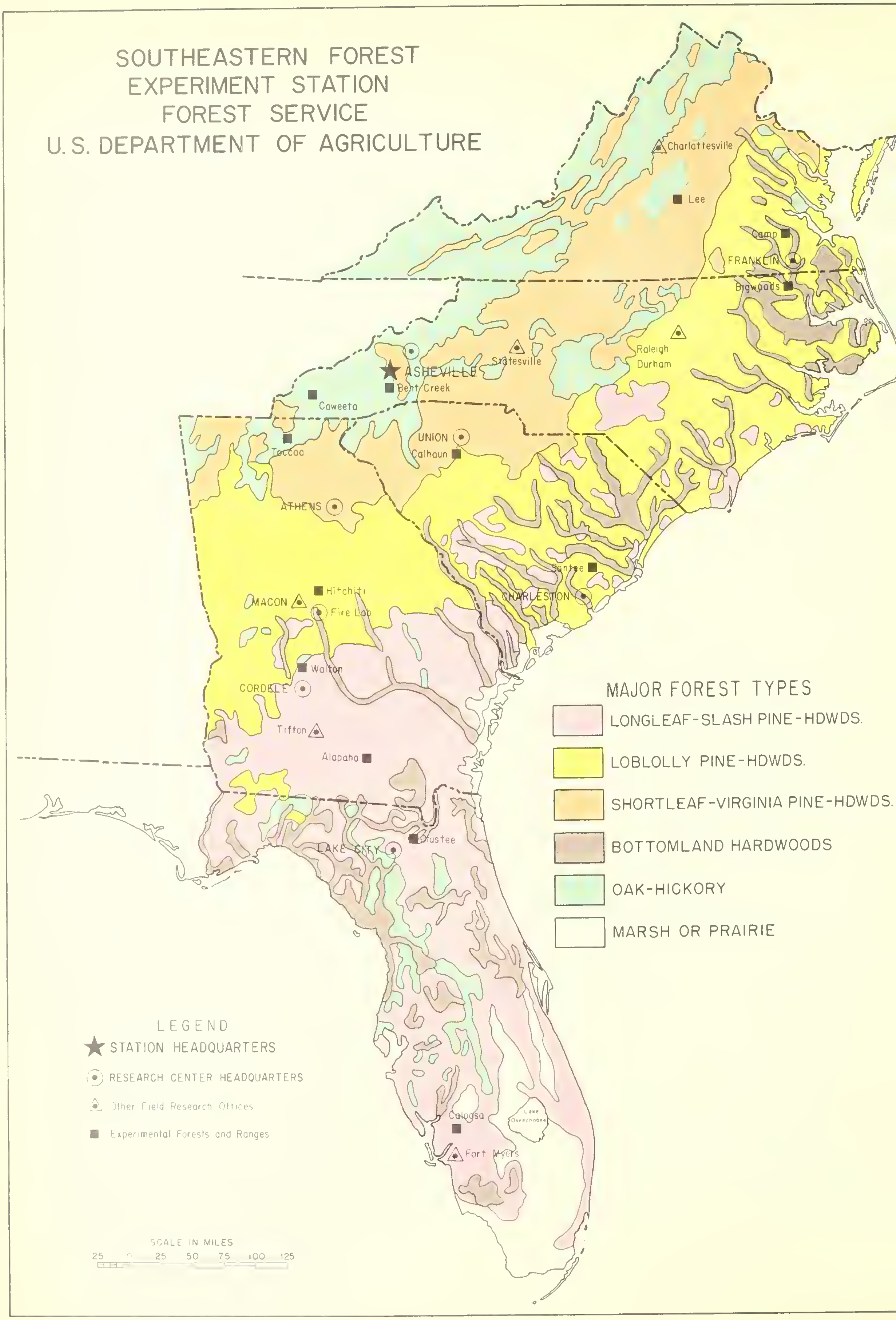
Union Research Center, Union, S. C.	Louis J. Metz

CONTENTS


SOUTHEASTERN FOREST
EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Charlottesville
Lee
Camp
FRANKLIN
Bigwoods
Raleigh
Durham
Statesville
ASHEVILLE
Bent Creek
Caweeta
UNION
Calhoun
Toccoa
ATHENS
Santee
CHARLESTON
Hitchiti
MACON
Fire Lab
Walton
CORDELE
Tifton
Alapaha
Olustee
LAKE CITY
Calosa
Lake Okeechobee
Fort Myers
MAJOR FOREST TYPES
LONGLEAF-SLASH PINE-HDWDS.
LOBLOLLY PINE-HDWDS.
SHORTLEAF-VIRGINIA PINE-HDWDS.
BOTTOMLAND HARDWOODS
OAK-HICKORY
MARSH OR PRAIRIE
LEGEND
STATION HEADQUARTERS
RESEARCH CENTER HEADQUARTERS
Other Field Research Offices
Experimental Forests and Ranges
SCALE IN MILES
25 0 25 50 75 100 125

1958 Annual Report
Southeastern Forest Experiment Station

INTRODUCTION

The tempo of interest in forest land resources keeps rising throughout the Southeast. This is accompanied by more and more queries concerning land management for timber and naval stores production, for water, forage, wildlife, and recreation. Protecting these resources from pests and fire becomes steadily more important. Such developments have brought an encouraging increase in forest research by colleges and universities, by forest industries, and by various units of state government.

Within this climate, a dynamic federal forest research program is essential — one that can reflect changes and provide needed guides; one that can complement the enlarging research programs of others; and one that provides basic knowledge for maximum progress of its own as well as other applied research programs.

Recognition of these needs results in constant change — reoriented program, improved training for our people, and modernized research facilities. Some changes strengthen existing programs, such as those in the mountain and adjacent Piedmont hardwoods of North Carolina. Some changes, such as the seed production work and seed research in Florida and Georgia, represent an attack on problems resulting from intensified forest practices. Others fill gaps in our program — for instance, management and improvement of wetland sites in South Carolina, research in wildlife habitat, and research in Virginia pine, shortleaf pine, and upland hardwoods in the Virginia Piedmont.

We have increased our efforts in basic research — a need repeatedly emphasized. Vital expansion in fire research and the physiology of flowering and fruiting in southern pines has occurred during the last few years.

An increased number of our research people are seeking advanced training in various specialized fields. This year

we have 17 of our staff at universities throughout the country doing advanced research and study in various phases of pathology, entomology, soils, ecology, tree physiology, physics, silviculture, statistics, economics, and wood products utilization.

Some major improvements in research facilities have begun. Highly trained men and the more complex problems with which they are faced require modern equipment and other facilities. This year saw the start of construction of a fire laboratory and a seed laboratory by the State of Georgia for cooperative use, and we received authorization to build a modern office-laboratory building for our Lake City, Florida, staff.

We have seen the expansion of team research — research that applies techniques and disciplines of many sciences to the solution of the more complex problems. This group effort is now being used in seed production research, where entomologists, pathologists, and silviculturists are jointly trying to determine how to produce adequate and reliable supplies of good quality seed from seed production areas and seed orchards. The task force approach is also being used in the study of nursery production, white pine blight, and other problems.

We are also attaining depth in attack by narrowing subject-matter coverage at research centers, each center being assigned major responsibility for different problems. For example, giving leadership in soils research to the Union Center will concentrate effort and speed progress.

These steps mark progress in getting our organization, people, and facilities geared to the forest research of tomorrow.

Joseph F. Pechanec

FOREST UTILIZATION

The long campaign for utilization of hardwoods is beginning to pay off. During the past year increasing amounts of pulp were made from hardwood, new products from hardwood veneer and plywood have appeared, growth patterns and knots are being used as character markings in hardwood panelling, hardwood use in particle board is up, and charcoal markets are expanding. Utilization research by federal agencies, colleges, and state agencies has played a part in these developments, and continued cooperation promises important advances.

Georgia Wood Residue Survey

Uses for the mountains of softwood and hardwood residue that are a byproduct of wood processing plants (such as slabs from sawmills) have long been a problem. Because residue utilization has to be done on a large scale to show a profit, questions of quantity available and cost of assembling it are fundamental. The potentialities of wood residue as a basic raw material for the manufacture of varied products including wood pulp, aggregated board, and many chemical compounds prompted the Georgia Forest Research Council, aided by the Georgia Forestry Commission, the Georgia State Department of Commerce, and the Georgia State Chamber of Commerce, to contract with the Station to study the wood residue situation in Georgia. A report published in December 1958 summarizes total residue volume, volume by districts, volume by types of industry, residue disposal, reported value of residue, and the volume available for consumption. The report also contains information on potential uses of residue.

All the timber-converting and wood-using plants of Georgia were visited by trained personnel of the Georgia Forestry Commission for the purpose of obtaining annual production figures, and data on the availability, value, and methods of disposal of wood residue by type of wood-using plant. In order to determine the volume and type of residue produced in these plants, it was necessary to sample plants from each type so that we could

Figure 1.—Weighing residue to develop conversion factors for a bed-spring-frame operation in middle Georgia.

develop conversion factors, which are the ratio of the volume of residue produced to the board-feet, cubic feet, or square feet (as the case may be) of raw material used in manufacture (fig. 1).

Annual production figures based on the 1957 survey period show that approximately 891 million board-feet of pine lumber and 229 million board-feet of hardwood lumber were manufactured in Georgia by 746 reporting sawmills. Also, wood treating plants processed almost nine million cubic feet of poles, piling, and fence posts; veneer and plywood mills used about 90 million board-feet of hardwood logs and a small undetermined volume of softwood logs; planer mills and flooring plants processed 665 million board-feet of softwood lumber and 116 million board-feet of hardwood lumber; furniture factories used a million board-feet of softwood lumber, 30 million board-feet of hardwood lumber, and almost 17 million square feet of mixed plywood; and miscellaneous timber-converting and wood-using industries used 22 million

board-feet of softwood lumber, 24 million board-feet of hardwood lumber, and over 3 million square feet of plywood.

From these manufacturing processes, a total of 3,751,344 tons (green weight) of softwood residue and 1,426,499 tons (green weight) of hardwood residue was produced, with sawmills accounting for 73 percent of the total. Of this total, 4,803,437 tons of residue are available for manufacturing purposes. The report shows that 2,813,922 tons of residue are being burned at the site, left on the site, or given away. Of the million tons currently being used, the majority is sold as pulp chips (fig. 2), and the remainder is used as fuel, poultry litter, and mulch.

The Relative Efficiency of Four Stacking Methods in Air-Seasoning Southern Pine Lumber

Four methods of stacking are commonly used to air season pine lumber in Georgia—the flat pile, unit package, crib pile, and end pile. An exploratory study at a Georgia yard in 1956 indicated that drying times differ and degrade varies by methods of stacking. A study made at more than 20 yards in Georgia evaluated degrade losses and differences in drying uniformity by the above stacking methods as practiced commercially. This study brought out the need to obtain additional data on the uniformity of drying and loss by degrade and to develop information on the rate of drying. During the past year

Figure 2.—Large volumes of debarked slabs and edgings leave this Georgia sawmill daily for a slab concentration yard, where they are chipped, screened, and sold to a pulpmill for pulp chips.

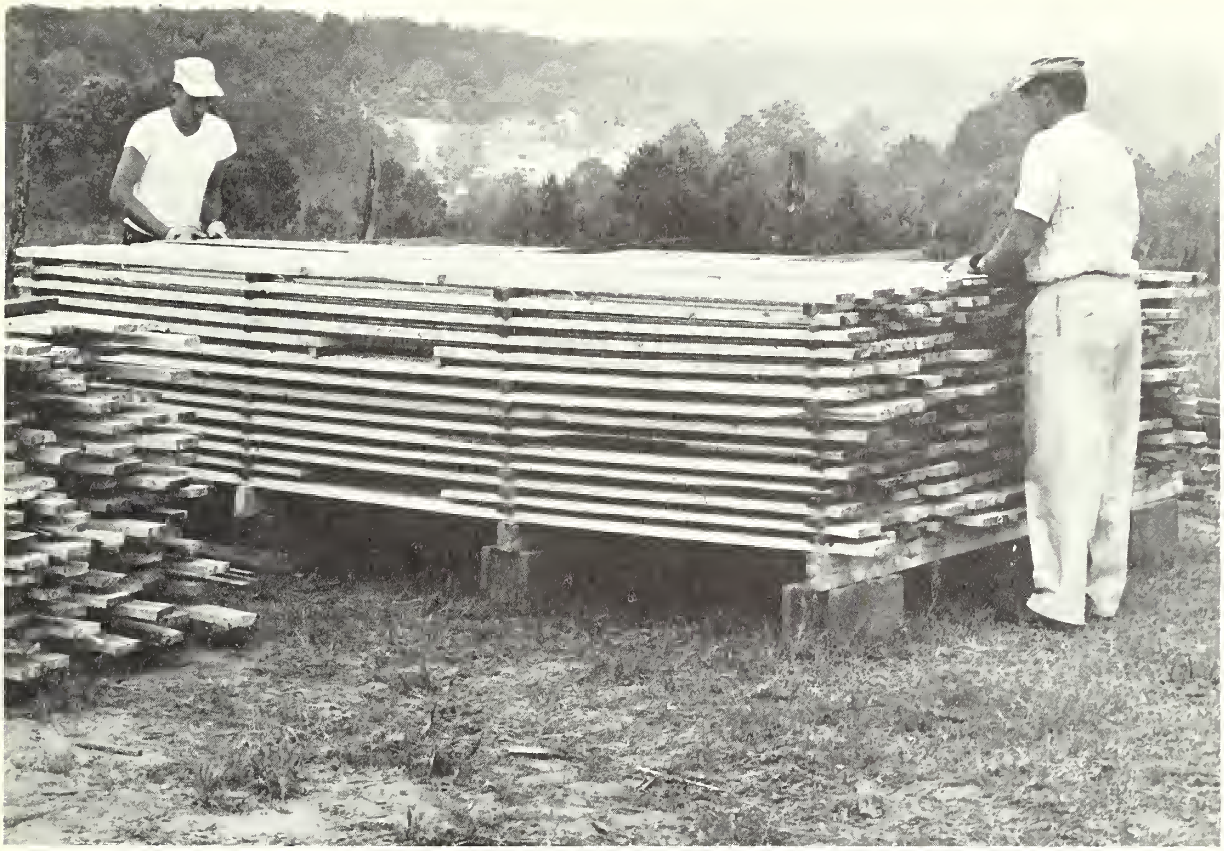


Figure 3.—Flat pile in process of construction, Hogan Brothers Lumber Company, Athens. One of several stacks used in a study of the "Relative Efficiency of Four Stacking Methods in Air-Seasoning Southern Pine Lumber." Pile was built to conform to approved stacking methods.

this information was developed.

Package-piled lumber averaged less in moisture content when torn down than did lumber stacked by other methods. Percentagewise, there were fewer boards and fewer individual moisture content determinations exceeding 19 percent in package-piled and end-piled lumber than in the other types of piles. Loss per thousand board-feet from seasoning degrade was less in package piling and end piling than in the other methods. While end-piled lumber about equals package-piled lumber in rate and uniformity of drying, end piling is not adapted to fork-lift handling. The current trend in Georgia is definitely towards mechanization, so it is fortunate that package piling rates high among the four methods most commonly used from the standpoint of drying lumber fast, uniformly, and with little loss from seasoning degrade.

These data indicate that the older, conventional method of flat piling (fig. 3) is the slowest method of drying lumber, and that crib-piled lumber does not dry satisfactorily under the laps.

Maximum Temperatures of Various Wood Elements in a House

Use of 2 x 4's made from glued 1 x 4's is on the rise in the building trade. For convenience and economy, the southern pine industry prefers the urea-resin glues for gluing these members. The glue, however, is subject to deterioration at temperatures of 120° F. and above, especially at high humidities. It is expedient, therefore, to determine the actual temperatures existing in buildings throughout the United States in order that temperature and humidity tolerances can be established for these glues.

Thermocouples were placed in a $12,000 brick veneer house being constructed in

Athens, Georgia. All thermocouples were placed on the unshaded south side of the house. August 11, 1958, was the hottest day of the month, with an air temperature of 94° F. at about 1:45 p.m. The exterior roof temperature at that time reached 148° F. The temperature between roof sheathing and rafters remained over 120° F. for about 1½ hours, while the center of the studs reached a maximum temperature of only 90° F. (fig. 4). Continued research over the country will establish useful data that can be used in house design.

Charcoal Studies

Some interesting and useful information has been obtained from the 33 charcoal burns made in the 7-cord masonry-block kiln located at Athens, Georgia. Numerous burns are necessary before many of the peculiarities of the kiln or burning variations become evident.

Researchers carried out several burns this past year using five chimneys instead of the usual three. The results were very similar to those obtained with only three chimneys. There was no decrease in coaling time and no increase in yield. The kiln generally required more supervision because more chimneys had to be sealed as they stopped smoking.

Some information has been obtained on the effect of moisture content on yield. Generally, green wood with a moisture content over 45 percent will produce extremely variable quantity yields, whereas seasoned wood will result in a relatively uniform conversion of wood to charcoal (fig. 5). Seasoned wood will generally produce about 31 percent charcoal yield (based on ovendry weight of wood) and the green wood will produce about 28 to 29 percent. Variation in yield when coaling green wood is often due to the amount of unburned wood (brands) remaining after the burn. Brand weight per burn varied from no brands to 2,800 pounds. It seems that such uncontrollable conditions as wind direction, weather, and density of wood stacking (which is related to straightness of wood) significantly influence the coaling of green wood

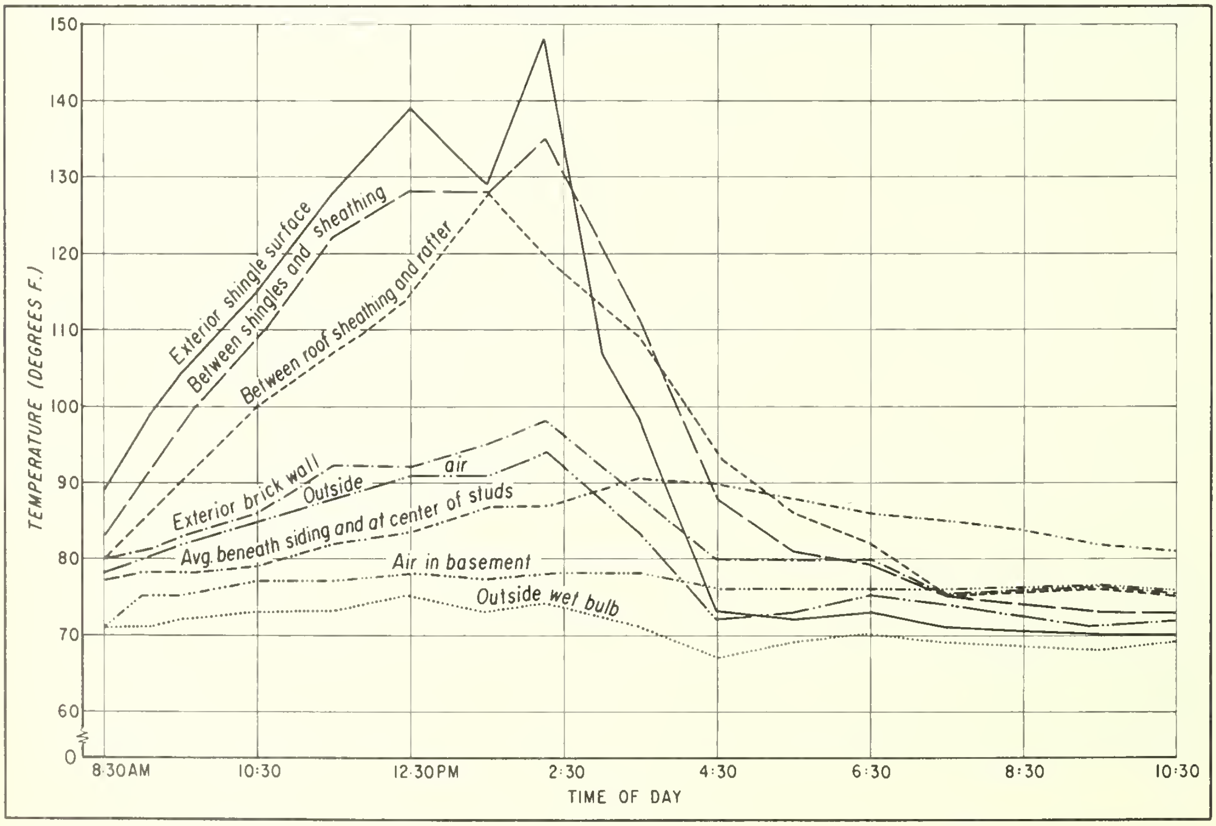


Figure 4.—Temperatures obtained at various locations in a house at Athens, Georgia, August 11, 1958.

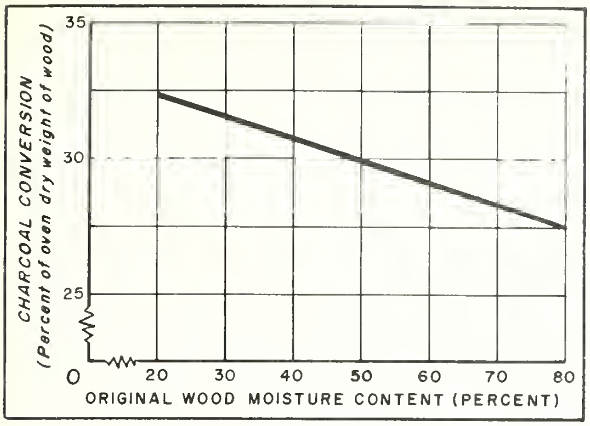


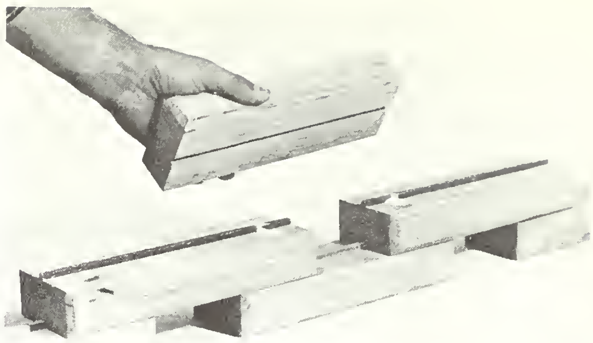
Figure 5.—Charcoal yields obtained at various wood moisture contents (7-cord charcoal kiln, Athens, Georgia).

but not dry wood. Any slightly adverse condition results in poor burning, with a large number of brands and consequently a low charcoal yield. Complete coaling of a green wood charge produces a charcoal yield as good as that from a seasoned wood load.

On a basis of experience gained from the 33 burns, we believe that the kiln front should face into the prevailing wind so that the ignition heat is blown over the kiln load. The reverse condition is true for the test kiln and probably has had a negative influence on the results.

Development of Wooden Brick

A new development in the use of low-grade hardwood lumber has taken the form of wooden brick for decorative interior partitions. During the past year, methods of unitizing this low-grade material to make a high-grade, attractive product were studied. Two simple and convenient methods for joining the brick were tested. One uses a narrow horizontal spline and the other a short vertical spline (fig. 6). Only glue is used, and the more-difficult-to-nail woods such as oak and hickory can, therefore, be used just as easily as the less dense species. Water-resistant glues and use of splines for alignment as well as for strength make the work foolproof. Because of the ease of assembly, a "do-it-yourself" market should be possible.



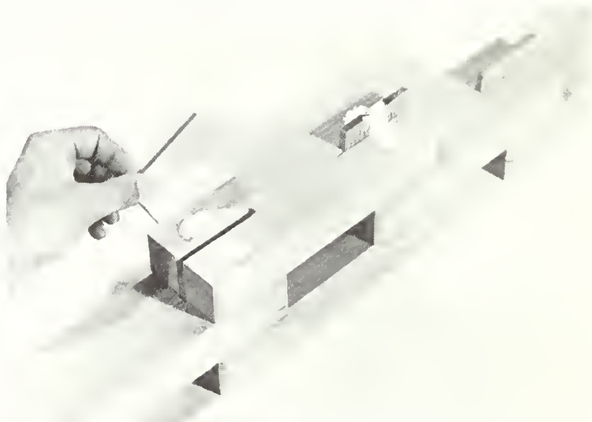


Figure 6.—Wooden brick joined by two simple methods which can be used by the homeowner.

Research in Forced-Air Drying of Lumber

Research on forced-air drying, or predrying, of southern lumber is being continued to determine the advantages of this method of seasoning, and to provide information for the design and operation of commercial predriers. One-inch pine lumber has been predried in 4 to 8 days from an average initial moisture content of 95 percent to an average final moisture content of 18 percent. A constant temperature of 80° F. and air velocities ranging from 200 to 1,000 feet per minute have been used. Little or no degrade has occurred. Under these test conditions, drying time was influenced as much by outside weather as by varying the air velocities. In order to determine the effect of air velocities and weather conditions separately, tests were made simultaneously at air velocities of 300, 550, and 800 feet per minute in three small

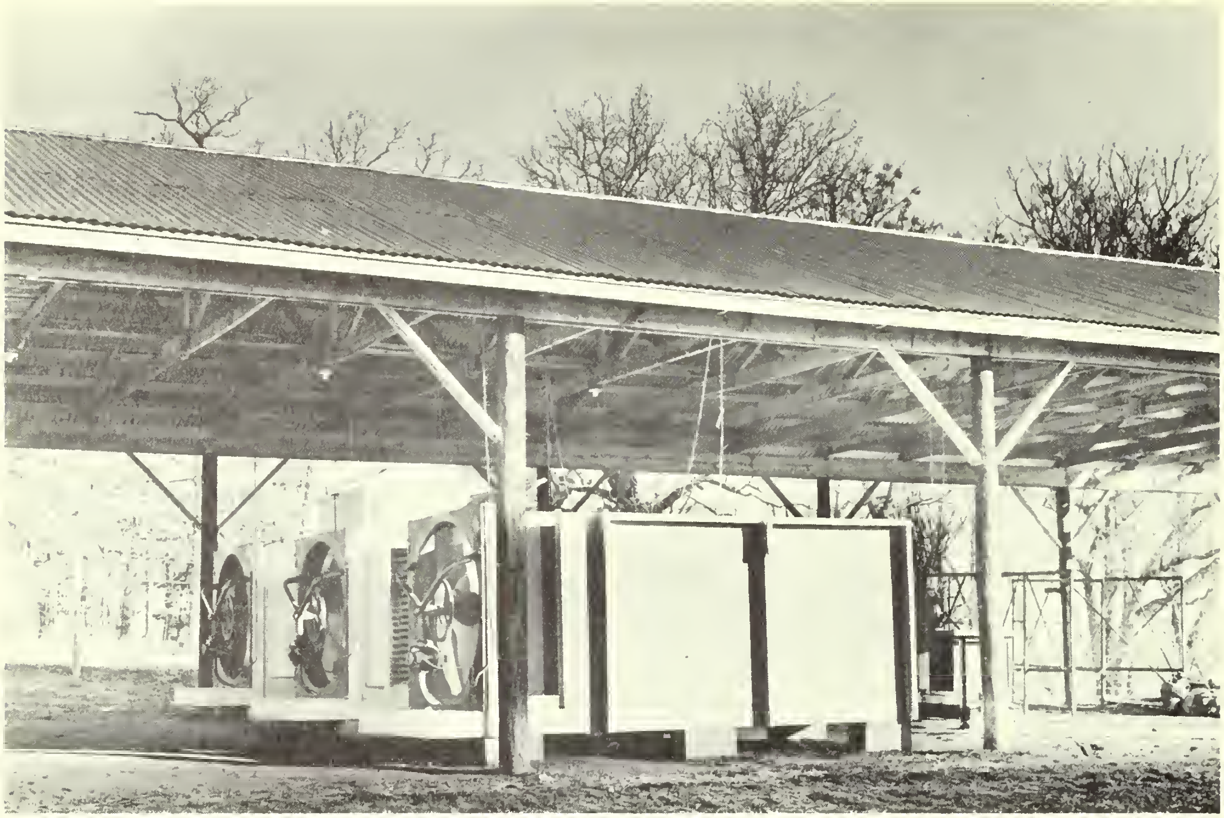


Figure 7.—Wind tunnels used for predrying tests. Several species or air velocities can be tested simultaneously so that all are subjected to the same weather conditions.

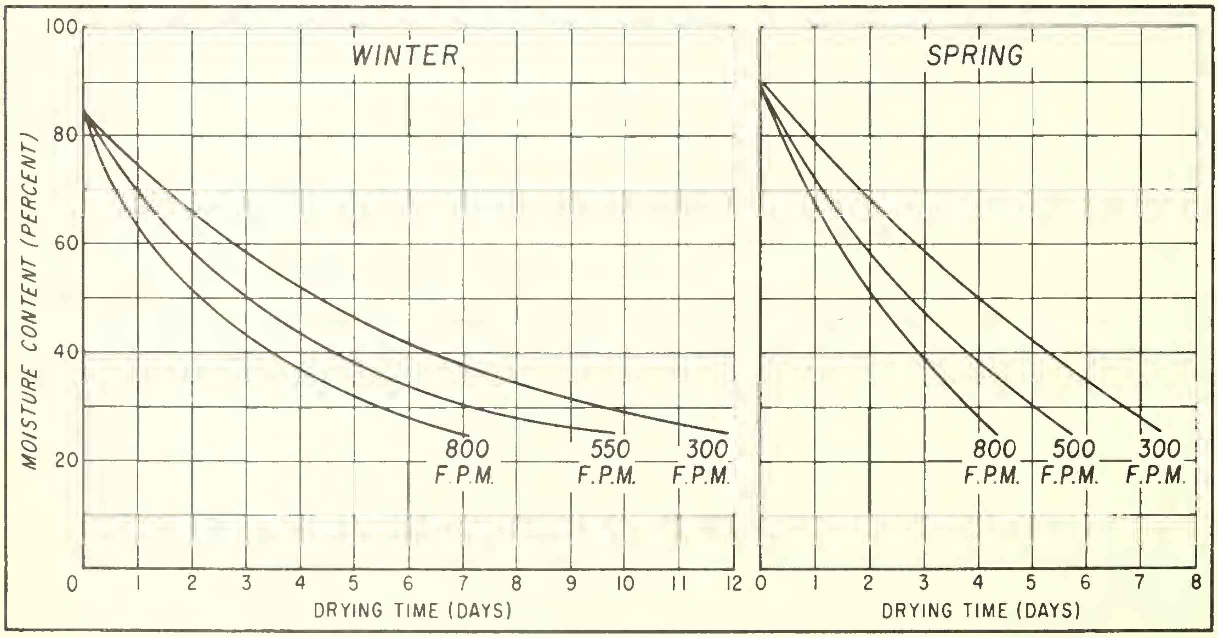


Figure 8.—Effect of air velocity on drying time of 4/4 southern pine lumber.

unheated wind tunnels during various seasons of the year (fig. 7). The results for winter drying were 12.0, 10.0, and 7.0 days respectively for the air velocities of 300, 550, and 800 f.p.m. In the spring months the drying times for the same air velocities respectively were 7.4, 5.7, and 4.3 days (fig. 8). These tests were conducted with green lumber and dried to an average moisture content of 25 percent. Wind tunnel tests and other tests conducted in a building maintained at 80° F. indicate that drying time to a moisture content of 25 percent can be reduced by 1 to 3 days with each air-velocity increase of 200 to 250 f.p.m. Tests in which fan-power requirements have been metered show, however, that the optimum air velocity is about 500 to 600 f.p.m. when the drying time and power consumption are considered together.

When a lumber dryer is operating with little or no added heat, the distance air must travel through a lumber load is important in controlling the total drying time, moisture content uniformity, and degrade from stain. Blue stain occurs readily in southern pine lumber under humid conditions at temperatures between 40° to 95° F. Results obtained in a small wind tunnel illustrate the effect of distance. Three sets of pine samples were placed 8 feet apart in a tunnel 16 feet long. Material for each set was cut from the same lumber. No heat was used, and an air velocity of 500 f.p.m. was maintained without recirculation. The drying time to a moisture content of 30 percent was 5 days for the samples at the air-entrance end, 11 days for the center samples, and 14 days for the samples at the air-exit end (fig. 9). Heavy blue stain occurred on samples located at the air-exit end of the tunnel. This points to the desirability of periodically reversing air direction and the need for caution in constructing predriers where air must travel a long distance through the load.

Satisfactory results in predrying 4/4 lumber have also been obtained by controlling the equilibrium moisture content rather than holding the temperature constant. In this method, heat is required only when outside e.m.c. is high. Heat requirements are considerably less during periods for low outside e.m.c. One-inch pine lumber green from the saw has been dried to an average moisture content of 15 percent in 4 to 6 days by means of air velocities of 500-600 f.p.m. and controlled e.m.c. between 9 and 11 percent. Lumber degrade was not significant. Temperatures reached 130° F. in tests conducted during the summer with e.m.c. controlled at 9 percent.

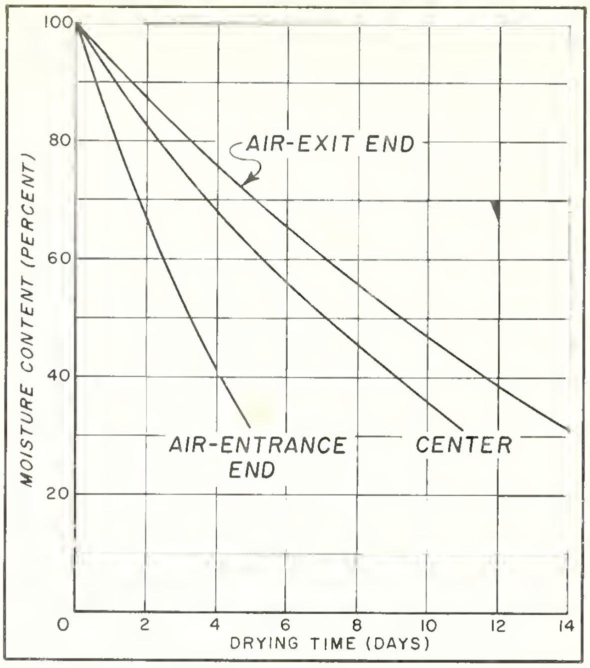


Figure 9.—Effect of length of air travel on drying time, 4/4 southern pine. Samples were placed 8 feet apart in the tunnel. Average outside air temperature was 76° F., average outside relative humidity 84 percent, and average outside e.m.c. 17.8 percent. Air velocity was 500 f.p.m. No heat was used.

Tests of other species are also being conducted. Mixed 4/4 pine, poplar, and gum have been dried with air velocities of approximately 650 f.p.m. and e.m.c. control at 10 percent. Temperatures did not exceed 120° F. Drying time for pine, poplar, and gum, green from the saw to an average moisture content of 18 percent, was 3.7, 6.9, and 8.4 days respectively. Degrade did not occur on pine or poplar, but surface checks in the heartwood of sap gum appeared on approximately 20 percent of the boards.

Studies of predrying 8/4 pine lumber are also under way. One load of 2 x 6 southern pine dimension has been dried in 7 days to average moisture content of 19 percent. Drying conditions were controlled so as to keep the maximum e.m.c. at 11 percent for the first 6 days and at 9.3 percent for the 7th day. Temperatures did not exceed 88 degrees and air velocity averaged 725 f.p.m. Degrade due to surface checking occurred on 34 per-

cent of the boards, probably because of the low e.m.c. No other degrade was noted. Further tests are scheduled at higher e.m.c. conditions.

The conclusions drawn from tests conducted during the past year indicate that e.m.c. control is desirable and should be set at approximately 11 percent for 4/4 southern pine. A maximum and minimum temperature control might also be incorporated into a forced air dryer regardless of e.m.c. to maintain temperatures within reasonable and desirable limits. The tests indicate that when e.m.c. is controlled by addition of low heat and an air velocity of approximately 500-600 f.p.m., good drying rates are obtained with a minimum of lumber degrade.

Wood Moisture Content Variation in Homes in the Southeast

The dimensional instability of wood poses a constant and perplexing problem to furniture manufacturers. Failure to manufacture furniture at the same moisture content it will have in use in the home usually results in loosening and tightening of joints, splitting, and checking.

In an effort to solve this problem, the U. S. Forest Products Laboratory made a study of the moisture content of wood in dwellings in representative cities throughout the United States. In view of the need for information about more localized conditions, the Southeastern Station in cooperation with the Southeastern Dry Kiln Club has undertaken studies in the Southeast. These studies to determine the moisture content variation in dwellings began in June of 1957 and have continued up to date.

Home moisture content determinations for one year demonstrate that the moisture content of wood varies widely by seasons of the year and in different parts of the house, as shown in figure 10. The largest variations occur during the fall and spring, and during these seasons, basements show the greatest moisture content changes. Thus, in the course of a year, wood in basements may change as much as 12 percent in the Piedmont and 9¾ percent in the mountains. Living areas showed less yearly moisture content variation, and attics the least. These variations are controlled to some extent by house construction, insulation, and heating systems, but in the best of houses, unfinished wood can

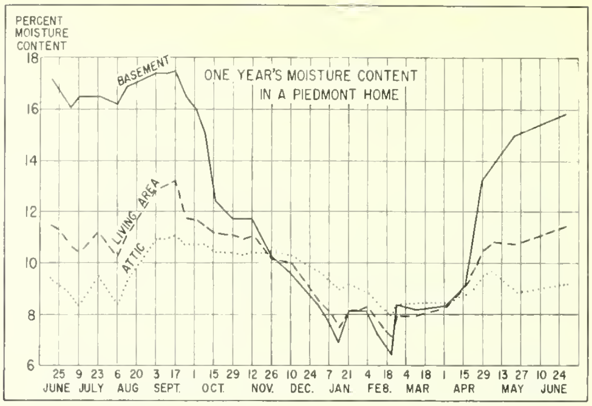


Figure 10.—Moisture contents plotted for one year in a Piedmont home show the wide variation in moisture content in the basement as compared to the more moderate changes in the living area and attic.

change in moisture content enough to cause serious damage to wood products.

The next step in this study is to ascertain the effect of finishes in retarding such changes and to develop recommendations not only on the factory moisture content of wood products but also on the methods to prevent changes that cause damage in the home.

Log and Tree Grade Studies in Southern Pine

Results from this past year's work indicate that the Interim Southern Pine Log Grades satisfactorily stratify pine logs into value groups throughout the area tested. These test areas with their respective study species are as follows: South Carolina (loblolly), Georgia (loblolly), Arkansas (shortleaf), Mississippi (loblolly), and Florida (longleaf and slash).

In comparing areas, however, it was found that the levels of value between comparable grades were somewhat different, and that these differences cannot be attributed entirely to biological differences. Extensive statistical analysis of the data has shown this to be a valid conclusion. Present indications are that these differences are at least partly caused by variations in milling practices and/or grading methods used at the various study areas. Confirmation of this supposition will involve collecting additional trees from

each of the above areas, shipping them to one mill, and conducting the sixth grade-yield study.

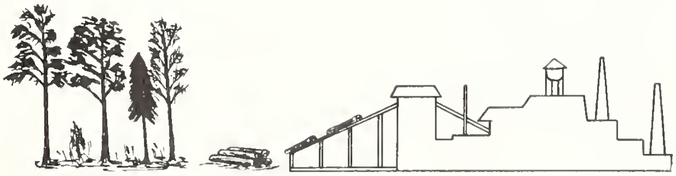
Throughout the past year, computations of pine grade yields and overruns by species and condition class have been prepared and put in use by the Southern Region of the Forest Service. This information will supplement their data used in appraisals and sales of National Forest pine lumber.

Hickory Task Force

Two Hickory Task Force Reports were published and distributed during the past year. John W. Lehman, Chief of Forest Utilization Section of TVA, prepared "Products from Hickory Bolts." This report presents information on the size, quality, and grade requirements of hickory bolts in use today. Specifications for a number of bolt products and comments on manufacturing methods are included. The other report prepared by Dean Allyn M. Herrick, of the University of Georgia School of Forestry, is entitled "Grading and Measuring Hickory Trees, Logs, and Products." Although there are no accepted standard grading systems specifically for hickory trees, logs, or bolts, Mr. Herrick has placed in his paper the grading systems developed by the U. S. Forest Service and Purdue University that appear to be suitable for hickory. Lumber grade yields have been determined for hickory trees and logs, as well as hickory product grades used by industry.

Service Activities

An intensification of service work in the form of technical assistance to forest products industries, presentation of technical papers, talks on utilization before various civic and educational groups, and conferences on research projects occupied much of the time of the Utilization Staff. This involved conferences and visits on the status of charcoal research, exploring a new process developed in Canada for the continuous carbonization and briquetting of sawdust, instruction in hardwood tree, log, and lumber grading methods and techniques, and similar work. Although our efforts have been directed largely to the solution of the more pressing problems of producers, processors, and users of forest products, the need for more basic research requires a continuing effort to ferret out basic research problems that may be recommended for study and analysis to the Forest Products Laboratory or to schools equipped and staffed to handle them.



FOREST FIRE

Construction work on the new forest fire laboratory near Macon, Georgia, is more than half finished, and the 2-story, $370,000 lab is scheduled to begin operating in 1959 (fig. 11). First of its kind in the U. S., it is a joint undertaking between the Forest Service and the State of Georgia. Funds for the building were made available by the Georgia Forest Research Council. Equipping and staffing by the Station are being made possible from recently increased Federal funds to step up forest fire research in the South. Frank Albert, Director of the Georgia Forest Research Council, deserves much credit for his part in converting the plans to reality.

Fire scientists at the lab will seek to learn more about natural laws that affect fire in the woods, and why fire responds in certain ways to weather and natural fuels. They will conduct basic research on principles relating to ignition and combustion of forest fuels, heat transfer, radiation and convection, fuel properties, and the physics and chemistry of extinguishing forest fires. They hope to develop new concepts of fire control that will be of use in the South and elsewhere.

As to men and equipment, we are in the fortunate position of gathering the best of both. The building will include a wind tunnel, water modelling room, controlled humidity and temperature chambers, combustion chamber, well equipped chemistry and physics labs, darkroom, offices, and conference rooms.

Headquarters for the Fire Research Division, under the direction of Karl W. McNasser, was moved from Asheville to Macon during the year. Research Meteorologist Dee F. Taylor, who joined the staff this year, was formerly one of the U. S. Navy's typhoon

Figure 11.—Architect's view of the new Southern Forest Fire Laboratory now under construction near Macon.

trackers and top air-weather reconnaissance officers; not the least of his achievements has been flying into the fury of 25 Pacific typhoons in winds up to 125 miles per hour and staying alive to tell about it.

To round out the staff, research engineers, research physicists, a soil scientist, and a statistician will be added to the fire group.

TESTING THE 8-100-0 METER IN THE LONGLEAF-SLASH PINE REGION

An analysis of the operation of the 8-100-0 fire danger meter in 10 key areas in 5 states from Georgia to Texas over a 2-year period has been completed. The objective was to determine how well the meter, originally developed for the predominantly hardwood forests of the Northeast, measures fire danger in the longleaf-slash pine region, where fuel types are different and there are more incendiary fires.

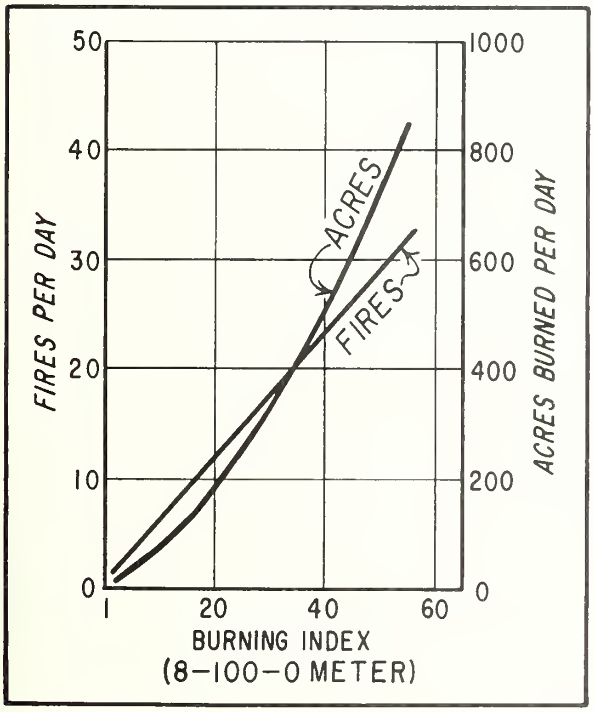


Figure 12.—Number of fires per day and acres burned per day versus numerical burning index classes on the 8-100-0 meter. Combined data for 10 key areas in five states in the longleaf-slash pine region, 1956. Class E fires not included.

In all key areas it was found that number of fires, including incendiary fires, bears an approximately straight-line relation to numerical burning index on the 8-100-0 meter. In general, as burning index doubles the number of fires also doubles. The relation for the 10 key areas combined for 1956 is shown in figure 12. Acres burned per day, which is one measure of job load, also is related to numerical burning index for all 10 key areas. This is so because more fires start, they burn faster, and are more difficult to control with worsening fire weather conditions.

From this analysis it appears that, because of the fairly regular increase in number of fires and acres burned per day with increasing burning index, the 8-100-0 meter is a reliable tool in fire control in the longleaf-slash pine region of the South.

An analysis report for each state has been prepared which presents results in more detail and suggests several applications of fire danger measurements in fire planning and evaluation of the job done.

CLASSIFICATION OF FOREST FUELS

Field work aimed at classifying forest fuels in terms of expected fire behavior was begun this year in coastal North Carolina. This new approach to fuel classification is based on thermodynamic concepts that treat fire behavior as an energy phenomenon controlled by the weather and fuel variables. To classify fuels in terms of expected fire behavior on a basis of energy and energy conversion processes requires a set of basic fuel factors such as described in the Station's 1956 Annual Report.

Study of total fuel energy was started first, since this fuel factor is of primary importance in blowup fires. Total fuel energy is the total heat content of a unit area of fuel, corrected for combustion efficiency; it is closely related to the total dry weight. In a blowup fire nearly all the fuel burns, and the total amount of fuel energy is released.

The 80,000-acre Hofmann Forest was selected for detailed analysis to develop techniques. All extensive areas of fuels that appeared different as to weight and species composition were described, and total dry weights by species were determined. Eleven types have been recognized, ranging in dry weight from about 6 tons per acre for a 3-year rough

type composed mostly of swamp cyrilla and fetterbush to about 16 tons per acre (not counting the overstory pond pine) for a very high brush type (figures 13 and 14).

It appears that the 11 tentative classes can be combined into perhaps 5 total weight (total fuel energy) classes, each of which will have a different potential for extreme fire behavior. Total fuel energy combined with the other fuel factors, including combustion period, critical burn-out time, and available fuel energy, should provide a classification of fuels covering behavior of fires of all intensities.

Figure 13.—Three-year-rough fuel type containing about 6 tons per acre of vegetation and litter.

Figure 14.—Very high brush type containing about 16 tons per acre of understory vegetation and litter.

AERIAL FIRE SUPPRESSION

Research on aerial fire suppression was begun this spring in Georgia and North Carolina. Fifteen calibration drops of kaolin slurry from a TBM aerial tanker were made in natural and planted timber types in the coastal plain of Georgia and North Carolina. Timbered types have not been calibrated extensively elsewhere. In addition, the effectiveness of borate and of wet water was observed on ten drops on test fires in natural pine timber types. Equipment and techniques used were similar to those developed in the West.

In each of the four Georgia types three calibration drops were made: single 220 (only 220 gallons released); double 220 (two drops of 220 gallons released with one superimposed on the other); and single 440 (440 gallons released at one time). Over-all pattern size for all three types of drops made from altitudes between 50 and 100 feet above ground or crown canopies was about 370 feet by 75 feet in all fuel types. Patterns were fairly uniform with no gaps of low concentrations. Two typical patterns are shown in figure 15.

The amount of slurry that reached the ground in a readily discernible pattern varied with the size of load, height of drop, cover type, and wind velocity. In the open, 86 percent of the 220-gallon load fell within the pattern boundaries; 65 percent of the double 220-gallon load; and 53 percent of the 440-gallon load. The 440-gallon drop was from 10 to 35 feet greater altitude than the other two drops. Catch on the ground for 440-gallon drops averaged 41 percent under medium-density pine plantations with no understory vegetation, 37 percent under open pond pine stands with dense understory vegetation, and 34 percent for medium-dense pond pine stands with dense understory vegetation. The differences in the amounts reaching the ground in the several types, as compared to the open, represent the amounts retained on the overstory and understory vegetation. Almost complete coating of the understory vegetation and surface litter was observed where the application rate was about 0.4 gallon or more per 100 square feet. Indirect attack with 440 gallons of borate slurry retarded an average of 275 feet and extinguished 255 feet of medium-intensity headfire, in medium-dense pond pine timber with dense brush or cane understory. Estimated minimum application rates on the ground of about 0.4 and 0.5 gallon per 100 square feet were required to achieve these results. Borate drops on similar fires in very open pond pine timber with similar understory vegetation retarded and extinguished 20 feet more line but required about 0.1 gallon per 100 square feet

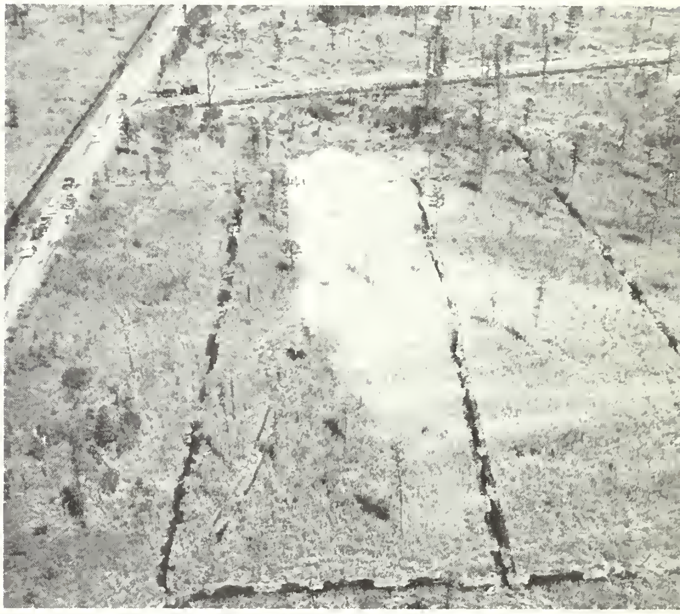


Figure 15.—Aerial views of stands, each having a heavy cane understory, after a drop of 440 gallons of kaolin slurry. Above, an open pond-pine stand. Below, a medium-dense pond-pine stand. (Photos by N. C. Division of Forestry.)

greater application rate. Observations indicate that these estimates do not apply to palmetto-gallberry fuel types, where heavier application rates apparently are needed.

Direct attack with 440 gallons of wet water on test fires achieved about the same results as indirect attack with borate in similar fuel types and under similar burning conditions. Two 220-gallon loads of wet water laid end to end extinguished a total of 400 feet of medium-intensity headfire or 200 feet on each pass in medium-density fuels.

Patterns for loads of both 220 and 440 gallons appeared to be sufficiently wide so that in no case was there a gap in the pattern which would allow fire to cross into uncoated fuel.

Time and cost were not considered in this study. However, on a basis of length of effective line built in proportion to the total length of pattern laid down the TBM shows promise as a fire suppression tool in the Southeast. Drops were placed with good accuracy and there were no difficult operational problems.

Results of these tests suggest that aircraft with both larger and smaller capacities than the TBM might profitably be tested as fire suppression tools, particularly in boggy areas, where trafficability for tractors, plows, trucks, and other standard fire-fighting equipment is poor.

MORTALITY INDICATORS FOR LONGLEAF AND SLASH PINE

In a mortality study of 480 longleaf and slash pines following the 110,000-acre Buckhead fire in March 1946 in north Florida, approximately equal proportions of large and small trees of both species died from equal amount of crown consumption. Nearly 9 trees in 10 died when more than half their needles were consumed by flame, and 4 trees in 10 succumbed when less than half their crowns were consumed. Even 100-percent needle browning caused no mortality, presumably because initial temperatures of the buds and cambium were low, about 45° F.

Height of bark char on the stem in percent of tree height also was found to be related to mortality. Approximately 9 trees in 10 died when 80 percent or more of the stem was charred, and 4 trees in 10 died when between 60 and 80 percent of the stem was blackened. Mortality was very slight where stems were charred to less than 60 percent of their lengths.

Above-normal rainfall and below-normal temperature conditions the first 3 months following the fire were favorable for survival of fire-damaged trees. However, the general drought condition that had existed in the area before the fire persisted for another year.

The mortality indicators developed in this study are limited in application to other situations having approximately similar conditions, such as air temperature (45° F.), fire (headfire), beetle (light attack), and post-fire weather (fairly normal). Air temperature was probably the most significant weather factor in reducing mortality. It is quite possible that mortality would have been double or triple had the Buckhead fire burned in an air temperature of 90° F.

METHOD FOR ESTIMATING DROUGHT CONDITIONS

Forest fire control becomes progressively more difficult during extended droughts. Aerial fuels become more flammable, firelines are hard to build and hard to hold, and fires burn with high intensity and rate of spread. A simple method for gaging drought severity would be helpful to men responsible for fire control in the South.

Work was completed this year on a preliminary method for estimating the amount of water in an inorganic forest soil profile. In operation, the observer proceeds as follows:

1. Selects one or more stations from which reliable daily precipitation and maximum and minimum temperature records are available.
2. Determines depth of tree root penetration in natural stands as an estimate of depth of soil profile to be considered.
3. Assumes water holding capacity to be 2 inches per foot of profile unless a specific figure can be obtained.
4. Selects a starting date in winter or spring when the soil profile is obviously saturated.
5. Computes the daily water balance by making daily subtractions of evapotranspiration values from the remaining available water. These values are based on mean temperature, and range from 0 to 0.32 inch. On days with rain, he adds the full amount of rain, minus the evapotranspiration value for the

day, to the water balance but not to exceed field capacity. He plots daily water balance over days.
6. During periods of low rainfall, he observes trends in the depletion curve and notes at what points fire suppression, particularly mop-up, becomes progressively more difficult because of lowered soil moisture.
7. From a series of such observations, he develops supplemental guidelines for fire-control action during drought periods.

FIRE BEHAVIOR

The Fire System Model

Fire behavior continues to be one of the main fields of study in our fire research program. The reduction of fire to its fundamental energy processes and component physical parts, and the determination of the interactions and relationships between these parts, amount to the establishment of a fire system model which represents the physical system needed to unify the various aspects of fire behavior. The term "model" is used here in an abstract sense and should not be confused with the term "scale model fire" used later.

Although not yet fully developed, a fire system model has been very effective in solving some of the more difficult problems of fire behavior and in gaining a better understanding of blowup fires. The effectiveness of such a model lies as much in the help it gives us in anticipating new fire-behavior situations and predicting new fire-behavior phenomena as in the explanations it provides for observed fire behavior. Also, the model tends to represent a physical system applying to all fires regardless of size and intensity.

There are four essential component parts in the fire system model. In its simplest form these are: (1) The earth's gravitational field, (2) a compressible fluid (i.e., the earth's atmosphere), (3) a boundary surface beneath the compressible fluid (i.e., the earth's surface), and (4) a heat source at or near the boundary surface. What is ordinarily considered a "fire," namely the flame zone where heat is being released, concerns only the fourth component of the fire system model. The combustion process as such does not enter into the fire model. It is significant only as an energy-producing agent for a certain type of heat source. Any other heat source not depending on the combustion reaction would work equally well if it were coupled by appropriate mechanisms to the other component parts of the fire system model.

The Energy Rate Number

By means of the fire system model and thermodynamic methods, certain basic fire behavior relationships can be expressed in terms of a dimensionless energy rate number. Some of these relationships were described at an earlier stage of development, in our Annual Report for 1956, in terms of power curves for the fire and the associated wind field. However, for some purposes, such as scaling problems for heat sources in a wind tunnel or in a slow-moving liquid, the energy rate number is simpler.

The energy rate number determines the over-all convective characteristics of a fire. For most ordinary fires burning in a brisk wind this number is small—usually less than 0.2 or 0.3. Such fires are of the forced convection type. If the energy rate number is greater than 1.00 the fire is a free convection type. If in addition the rate of energy output is high, such a fire is likely to develop blowup characteristics. For such fires there is usually a zone above the fire in which the energy rate number increases rapidly with height. This zone corresponds to the zone in which the wind speed decreases with height.

For a heat source in air the energy rate number N_e is

$$N_e = \frac{2 g I}{T_0 c_p \rho v^3}$$

where g is the acceleration due to gravity, I the intensity of the heat source or its rate of energy output, c_p the specific heat of air at constant pressure, T_0 the air temperature at the earth's surface, ρ the air density, and v the wind speed. To maintain convective similarity between two fires of widely different intensities, such as a small-scale model fire and a full-scale fire, it is essential that the energy rate number be the same for both fires. If they are burning in the same atmosphere, that is, if T_0 and ρ are the same for both fires, then the requirement for equal energy rate numbers leads to the scaling equation

$$\frac{v_m}{v_f} = \left(\frac{I_m}{I_f}\right)^{1/3}$$

Although the subscripts m and f refer to a model fire and full-scale fire respectively, the scaling equation holds for any two fires

with the same energy rate number.

For an incompressible liquid the equation for the energy rate number is

$$N_e = \frac{2gI}{k\, c_p \rho v^3}$$

in which k is the reciprocal of the temperature coefficient for volume expansion. This equation is identical to that for a heat source in air except that k replaces T_0. If a full-scale fire is to be represented by a heat source in a slow-moving liquid, the scaling equation becomes

$$\frac{v_m}{v_f} = \left[\frac{(T_0)_f}{k_m} \; \frac{(c_p)_f}{(c_p)_m} \; \frac{\rho_f}{\rho_m} \; \frac{I_m}{I_f}\right]^{1/3}$$

This equation gives a much smaller value for the $\frac{v_m}{v_f}$ ratio than for a heat source of the same intensity in air.

The Weightless Gas Equivalent of a Heat Source

One of the most instructive forms of the fire system model, especially with respect to blowup fires, can be obtained by replacing the fourth component of the fire system model (the heat source) with an energy source that does not involve heat. This energy source can be either a hypothetical gas of zero density, or a real gas of low density such as helium, which is supplied at a rate which can be accurately calculated in terms of an equivalent heat source of a given intensity. At the normal barometric pressure of sea level, about 1,100 cubic feet of weightless gas (or about 1,300 cubic feet of helium) per second per foot of fire front would be equivalent to a heat source of 1,000 Btu per second per foot. This would be considered a fairly hot fire with flames about 9 feet high. For a major fire of 20,000 Btu per second per foot with flames 60 to 100 feet in height, the total rate of supply of the weightless gas equivalent would have to be 2.3×10^7 cubic feet per second for each 2 miles of fire front. This would be roughly one cubic mile of weightless gas every 100 minutes. The helium equivalent would be about one cubic mile of helium every 85 minutes — a rate difficult to comprehend.

One of the main contributions resulting from substituting in the fire system model either the hypothetical weightless gas or the helium equivalent is the insight it gives into the fundamental nature of fire behavior. It indicates that the convective phenomena which dominate extreme fire behavior can be duplicated by an energy source which involves neither combustion nor even heat as such. For example, the turbulent motions in the convection column over a high-intensity fire, as well as the whirlwinds and long-distance spotting, should remain unchanged if the fire were taken away and large quantities of helium gas released at the appropriate rate over the previously burning area. However, for the helium source the "embers" would be cold. The buoyancy of hot gases resulting from the combustion process represents potential energy. The same is true of either helium or a weightless gas which has buoyancy at ordinary temperatures. In either case the potential energy converts to kinetic energy as the gases travel upwards. Violent convective phenomena are basically a function of the buoyancy of the convection column gases rather than the process such as combustion, by which the buoyancy is produced. The relationship between combustion and fire behavior thus appears to be of an incidental nature rather than a direct cause and effect. This point of view could have a pronounced effect on fire behavior research.

WINDS-ALOFT MONITORING STATION ESTABLISHED

The relation between certain types of wind profiles and extreme fire behavior has been reasonably well established through past research by the Division. Eventually we hope to be able to predict such profiles hours or days in advance. Until then, however, we can obtain some degree of warning by taking soundings of the winds aloft in high hazard areas on days when fire danger is building up.

The first winds-aloft monitoring station was established this fall near New Bern, North Carolina, in cooperation with the North Carolina Division of Forestry (fig. 16). Balloons are released at specified times according to the buildup and burning indexes on the 8-100-0 meter. Readings with a theodolite are taken periodically to a height of about 6,000 feet and the wind profile plotted. A double theodolite installation to give precise measurement of the speed of upper winds has been set up at Dry Branch, Georgia, for research purposes.

Figure 16.—Tracking a pilot balloon with a theodolite to chart wind speed and direction aloft. Wind profiles so obtained can give warning of extreme fire danger when fuels are dry.

The fire behavior that can be expected for wind profile types can be estimated by reference to an interim report, "Key-Vertical Wind Profiles and Associated Fire Behavior in Flat Country," prepared by the Division. Expected fire behavior can then be carried into the action phase on a going fire or used in presuppression planning.

UNIFIED FIRE DANGER SYSTEM

During the past 20 years the use of fire danger measurement has progressed far beyond the testing stage and is today universally recognized as a key tool in fire control management. Unfortunately, there is no uniformity in measurement techniques or application. Though the need for precise fire danger information is nationwide, the factors recognized, the method of measurement, and their integration in a scale of fire danger vary widely in the different regions of the country. Since combustion and fire behavior follow the same natural laws everywhere, the multiple variation in existing fire danger systems serves to confuse rather than to clarify.

In response to a long-felt need, representatives from Fire Research, Fire Control, and State and Private Forestry met in Washington last January to explore the possibility of developing a national fire danger measuring system. The committee members unanimously agreed that a unified system based on weather variables for standardized fuels was entirely feasible, and recommended a research project be set up. In line with the committee recommendation, a staff position was created in the Washington Office Division of Fire Research. John Keetch was assigned to head up the project, with field headquarters at Asheville, N. C.

TRENDS IN NUMBER OF FIRES AND ACRES BURNED IN THE NORTHEAST

Forest fire and fire danger analyses have been prepared annually since 1943 for each of 13 Northeastern states from Kentucky northeastward to Maine. A composite tabulation for all states for the period (figures 17 and 18) provides a revealing summary of the relative progress in fire prevention effectiveness and suppression accomplishment on state and private protected land.

In figure 17, the total number of fires, the burning index in thousands of units, and the number of fires per thousand units, are

plotted by years. The top graph indicates that there has been no definite trend in total number of fires during the period. But the center graph shows that burning conditions have decidedly worsened. When occurrence rates, i.e., number of fires per thousand units, are plotted as in the lower graph, there is a pronounced downward trend. This trend throughout most of the period means that substantially fewer fires have occurred from year to year for similar amounts of fire weather. Because there has undoubtedly been an increase in potential human risk during the analysis period, we can safely assume that prevention efforts have been highly successful.

The relative progress in reducing the area burned by forest fires has also been appraised by plotting 3-year moving averages of the number of acres burned per million acres protected per thousand units of burning index (fig. 18). The burned-area-rate trend of the lower curve in the figure indicates a decided and fairly persistent improvement in suppression accomplishment when Class E fires — 300 acres or larger — are excluded. Unfortunately, this does not hold true when all fires are considered (upper curve).

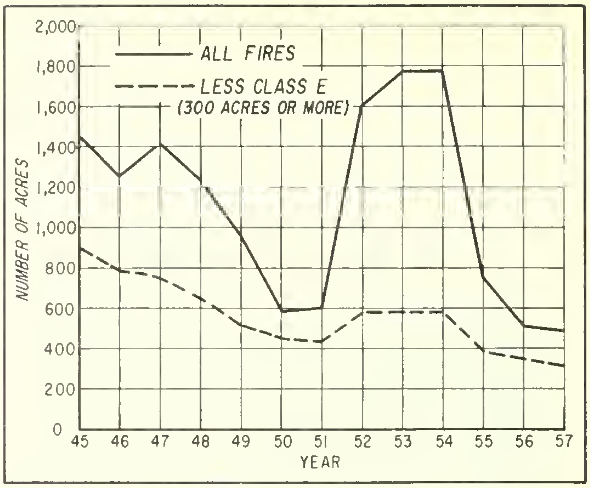


Figure 18.—Burned area rate (number of acres burned per 1,000 units of burning index per million acres protected) for 13 Northeastern States, 3-year moving average, 1943-57.

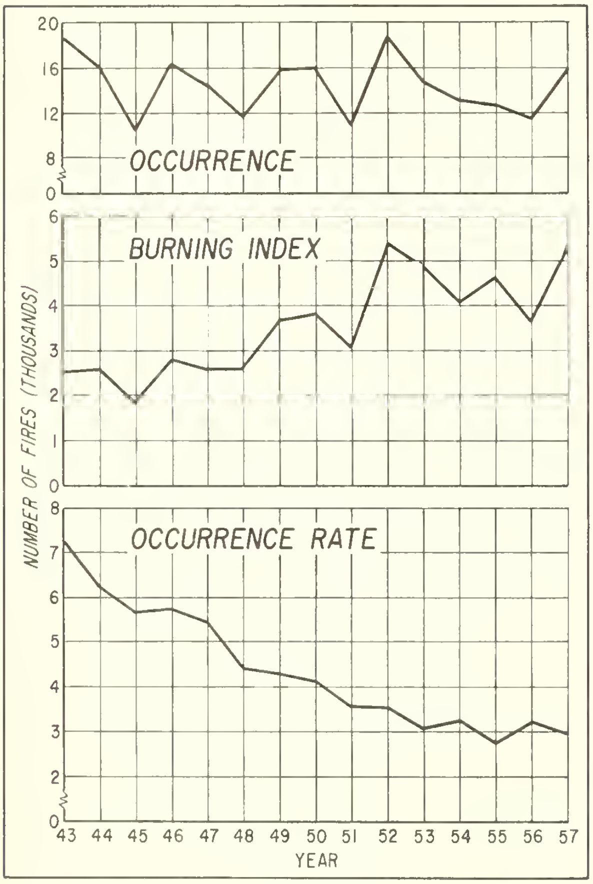


Figure 17.—Occurrence, burning index, and occurrence rate (number of fires per 1,000 units of burning index) for 13 Northeastern States, by years, 1943-57.

Fire control men are aware that a relatively few fires cause a relatively large percent of total acres burned. This fact is brought out by comparing total number of fires and acres burned with Class E fires and acres. During the 15-year period, somewhat more than 208 thousand fires burned almost 5 million acres. But 2,400 Class E fires (1.2 percent) burned almost 2¾ million acres (55 percent). This emphasizes the fact that sustained improvement in fire suppression is contingent upon designing fire control organizations better geared to handling emergency conditions.

WATERSHED MANAGEMENT

Station research in management of forest lands for water production and related purposes has been under way about 25 years at the Coweeta Hydrologic Laboratory located near Franklin, N. C., and on a more limited scale since 1947 on the Calhoun Experimental Forest near Union, S. C. Although the Coweeta experiments are widely known for mountain catchments to test streamflow response from cover alteration and other land treatment, the research there is being geared increasingly to basic plot-laboratory studies of watershed processes, particularly those governing evapotranspiration and other important water losses. Activities during the past year reflect this shift in emphasis, with greater effort on fundamental studies of soil-moisture-plant relationships.

Related to these activities was progress on studies of the physiology of water use by forest trees, long under consideration and much needed. Toward the end of the year, arrangements were made for starting a study on techniques for measuring moisture tensions in forest trees; also a related study to ascertain whether such values are possible indicators of water use requirements. This work will be conducted at Duke University by John Hewlett of the Coweeta staff. Such research holds many of the answers needed in assessing the consumptive demands of various cover types as well as other factors affecting water loss and yield.

Forest Soils Work at Union

With the present emphasis on fundamentals, project work in forest soils has increased at all the Station's research units. Since this work contributes to most functional lines of research, it was thought desirable to concentrate Station efforts at one place for greater efficiency. Accordingly, during this past year the activities of our Union Research Center have been reoriented to provide leadership in soils research, advice and assistance to all centers and divisions on forest soils problems, and training opportunities for other research workers.

Relations Between Timber and Soil Moisture in the Piedmont

A lot of water is removed from the soil as vegetation transpires. During the long warm summers in the Southeast, this process is so active that most of the rainfall is lost to the atmosphere before it can penetrate a foot or two of soil. After the first flush of spring growth, much of the soil moisture in the root zone may therefore be reduced to the wilting point by direct evaporation and transpiration, and by the latter process at greater depths.

If vegetation is shallow-rooted, as are some grasses, the dry zone may not extend deeper than the surface foot or foot-and-a-half, with ample moisture in the lower soil layers. However, in timber stands, even under young pines only 10 or 12 years old, the roots will often use all available soil moisture to a depth of more than eight feet. Since it is impractical, at least so far, to turn precipitation on and off, other means must be sought to get maximum benefit from that which falls. One way may be to thin timber stands so that there are fewer trees to use the available water. This may make more water available for streamflow or groundwater storage; and with extra sunlight, the crop trees should increase their growth.

To see just how soil moisture is influenced by stand density, part of a 17-year-old loblolly pine plantation on the Calhoun Experimental Forest near Union, South Carolina, was thinned in 1957 so that half the basal area was removed. Moisture was then sampled on thinned and unthinned portions of the stand by driving a 1-inch-diameter tube into the soil and extracting and weighing the cores for moisture content.

In the surface foot of soil, evapotranspiration removed water quite rapidly under both stand conditions. Depletion occurred, however, at a much slower rate in the thinned stand, and this layer of soil contained available moisture for tree or seedling growth 15 days after the moisture in the same soil zone under the unthinned stand had reached the

wilting point. Moreover, the thinned stand contained an inch more water in the surface 4 feet of soil after 30 days of drying (fig. 19).

During the dormant season following thinning, winter rains recharged soil moisture to a depth of 8 feet under the thinned plantation, whereas complete recharge did not occur below the 4-foot level in the unthinned stand. While these doubtless are not maximum differences in moisture content for thinned and unthinned Piedmont stands, they illustrate important relationships affecting water yields, stormflow, and tree regeneration and growth.

The difference in moisture levels on the Calhoun plots has persisted for two growing seasons. Although it is not known how long these differences will continue, it can be surmised that evapotranspiration losses from the two plots will soon equalize as roots and crowns of the thinned trees expand.

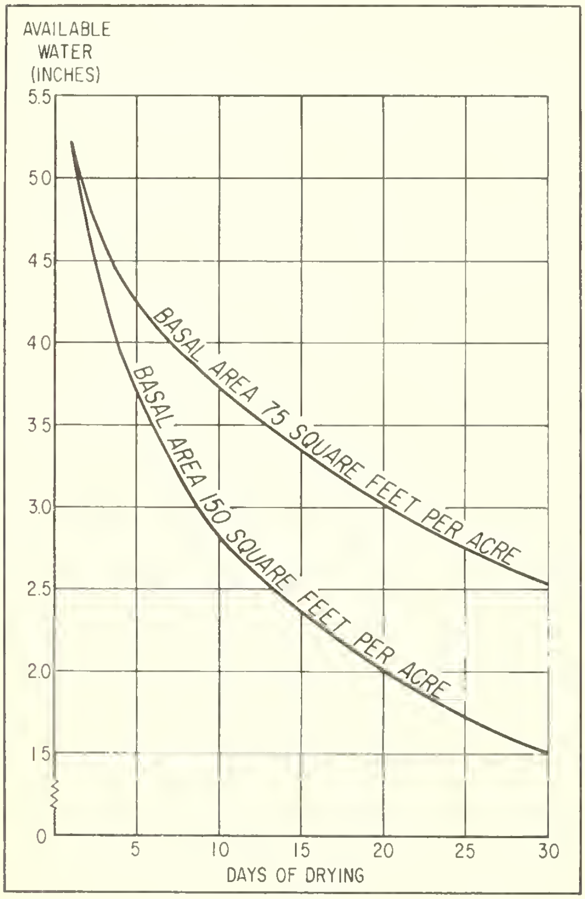


Figure 19.—Moisture depletion from the upper 48 inches of Piedmont soil in a thinned and an unthinned loblolly pine plantation.

Soil Moisture Sampling by Neutron Method

One of the continuing difficulties in studies such as the Calhoun plantation plots described above concerns measurement techniques in collecting sufficient data so that small differences between plots can be detected and effect of treatment reliably assessed. Gravimetric sampling, which necessitates driving a tube to a depth of 8 feet fifty times or more every time samples have to be collected, and processing literally hundreds of these samples to get the answers, seems impractical in our studies; and experience shows that unless large numbers of them are taken, reliable answers cannot be had. This long-standing problem of accurately measuring soil moisture quantitatively and its fluctuations on plots or other unit areas still troubles technicians and is everywhere handicapping watershed management research. One possible solution to this problem is use of the neutron-scattering method for measuring soil moisture. This procedure, now under test at the Coweeta Hydrologic Laboratory, shows considerable promise as a means of detecting quite small changes in soil moisture content and will be tested soon under Piedmont conditions.

Watershed Cover and Water Yields

Whether changes in cover type appreciably affect water yield is a commonly asked question. To afford some answers, a carefully controlled experiment utilizing 5 treated watersheds is now under way at the Coweeta Hydrologic Laboratory to get some gross measures of the differential effects of cover type on water yield for actual drainage units.

Essentially, the conception or premise is that one type of plant cover may consume more or less water than another and hence the right manipulation of cover will pay off in greater streamflow. Converting watershed cover from trees to grass or perhaps low-growing shrubs is one prescription which will seem a logical course of action where water supplies become critical and other sources or alternatives are not available. But whether this or other changes in cover type will produce more water for specific situations of terrain, soil, and climate is highly uncertain and unpredictable at this stage.

Of perhaps more direct implication for foresters are the huge tree-planting programs now under way in the Southeast, and the speculation these programs engender as to probable watershed influence. Pines are commonly being planted to convert inferior hardwoods to stands of commercially valuable trees. Unquestionably, these plantings are creating major watershed benefits, particularly where better cover is needed in sparse stands and open areas. But foresters and other conservationists are concerned whether the shift to pine in the long run may unfavorably affect soils and site quality, and whether the pines will make greater demand on water supplies.

Although hardwoods are commonly thought to use more water than pines, there is not much evidence one way or the other. The Coweeta study, started in 1955, will compare water-yield responses for a series of calibrated watershed units averaging about 30 acres in size and representing: (1) natural hardwood forest, (2) white pine on north and south exposures, (3) perennial grass, and (4) shrub cover. One of the units now planted wholly to pine is Watershed 17, which formerly was clear cut and then cut back annually in a classical, well-known experiment; and the other white pine unit (southerly exposure) was cleared of hardwood forest and planted in 1956 (fig. 20).

Figure 20.—Planting white pine seedlings on a clear-cut Coweeta watershed in an experiment comparing water yield from several cover types.

Figure 21.—Test planting of white pine on clear-cut Coweeta Watershed 17. Planted 1945.

The conversion from forest to grass is now in progress on the unit scheduled for this treatment. Plans for converting a fourth drainage from high forest to shrub cover are under consideration, though contingent on further study as to species, maintenance requirements, and the like. All the drainages have been gaged for about 20 years prior to type conversion; and plans call for long-term observation of the pine watersheds to fully document soil-site and other changes.

Of special interest to visitors are the 1945 test plantings of white pine on several small plots on the north-facing Watershed 17 (fig. 21). The aim was to see how well the pines would do on these sites. The plantings, now in their 14th year, are growing vigorously, with many of the trees 30 feet or more in height. The dense canopy has long since closed and eliminated hardwood sprouts and understory vegetation; it has blanketed the steep slope with a deep layer of protective pine litter (fig. 22).

Comparison with nearby hardwood forest like the original stand occupying this site shows somewhat less incorporation of humus with mineral soil under the pines but a greater total depth of litter plus humus. Infiltration tests and other observations indicate no impairment whatever in capacity of these soils to take in and store water; and indeed the soil under pine, as under the original hardwoods, can wholly absorb any Coweeta rainfall of record without causing overland flow.

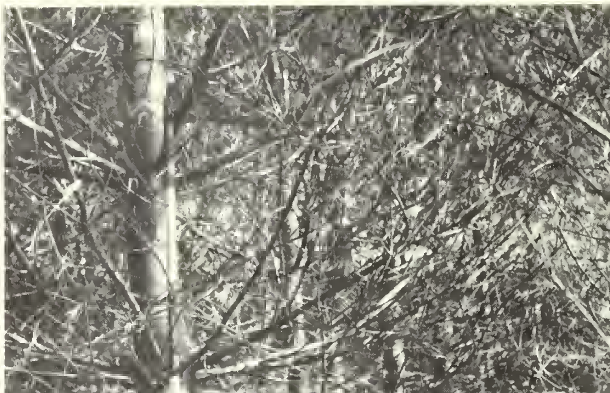


Figure 22.—Forest floor under 14-year-old white pine. This is the interior of the test planting shown in figure 21.

RANGE MANAGEMENT

Of special interest are new game habitat management studies, long sought by forestry and wildlife interests in the Southeast. To head up the new activity, Dr. Thomas Ripley, a biologist with degrees in wildlife management from the University of Massachusetts and Virginia Polytechnic Institute, and research experience in state programs, reported for duty as Station Staff Biologist in July. First effort has gone into an appraisal of game habitat research needs and regional study priorities, with particular emphasis on problems in (1) evaluating the forest and animal responses from timber cultural practices and (2) managing badly overbrowsed deer ranges. To strengthen animal biology phases of the research, Frank Johnson, who for many years has coordinated Federal-Aid work for the State of West Virginia, has been assigned to the Station by the Fish and Wildlife Service for cooperative work, with headquarters in Asheville. He reported for the new assignment at the close of the year.

Cooperative range research to help landowners make best use of forage in the piney woods country continued at Tifton, Georgia, and Fort Myers, Florida, with notable progress at both locations.

The changing situation in woods grazing in south Georgia and adjacent longleaf-slash pine country received special review and attention during the year to guide future range studies at Tifton. Here, some 16 years of productive research, undertaken cooperatively with the Georgia Coastal Plain Station and the Agricultural Research Service, has developed practical methods of using native forest range effectively in conjunction with feed supplements. However, a new stock law in Georgia, declining interest in woods grazing by many large land holders, and other factors are operating to greatly reduce woods grazing in the old pattern. But at the same time there are many new developments — the trend toward cut-and-plant forestry, even-aged management of timber stands, greater use of large-scale site preparation for longleaf planting, and the like — which can greatly enhance opportunities for forage production in southern woodlands.

Probably the best research studies for serving the needs of timberland owners under the changing situation are those that demonstrate ways of grazing cattle in young slash pine stands, both natural and planted. Accordingly, the Tifton program calls for greater emphasis on studies of grazing impact on slash-pine stands, and how to minimize tree damage; forage production and responses to site preparation, fertilization and other cultural practices in managing pine plantations; and related research to enable more profitable dual-use of forest holdings.

An important event furthering range and other forest research efforts in the South was a 1-week symposium devoted to methods and techniques for measuring forage and other understory vegetation. Jointly sponsored by the Southeastern and Southern Forest Experiment Stations, the symposium was attended by some 60 foresters, range specialists, and wildlife biologists.

Another newsworthy development was the start of work at Duke University by J. B. Hilmon, of the Fort Myers staff, on the fundamental biology and environmental requirements of saw-palmetto. This widespread undesirable is a major problem in fire protection, and its control is also of great importance to timber and beef producers.

Integrating Timber and Cattle Production on Intensively Managed Pastures

How to raise trees and cattle together profitably on piney woods range poses some management difficulties which concern many landowners in the Southeast. Key problems include (1) getting a greater output of quality forage yearlong; and (2) successfully regenerating slash pine stands with minimum damage to reproduction from prescribed burning and grazing. Consequently, on the Alapaha Experimental Range near Tifton in Berrien County, Georgia, a study was commenced in 1954 in cooperation with the Georgia Coastal Plain Experiment Station and the Agricultural Research Service. The

idea is to establish improved stands by means of fertilizer in slash pine plantations and to graze cattle while the trees grow to marketable size.

During the winter of 1954-55, slash pine trees were planted (two spacings) and 4 common pasture grasses (carpet, coastal bermuda, Pensacola bahia, and dallisgrass) on 2-acre test units; all units were clean-cultivated, fertilized, and limed.

Cattle were turned into the plantations on May 1, 1956, when trees were from 1 to 4 feet tall. Grazing damage was immediately evident, and by the end of May was prevalent in all plantations despite an abundance of high-quality, palatable forage. At this time elongating terminal and lateral buds were injured and lateral branches were broken. Subsequently, during the summer, browsing of pine foliage and mechanical damage was most pronounced for trees 2 to 4 feet in height. By November, foliage losses exceeded 50 percent on most trees, and 20 percent were dead. Injury to foliage and branches of trees 5 feet and higher was not excessive, however.

This phase of the Alapaha study demonstrated some of the pitfalls in trying to raise trees and cattle together when animals are confined to small areas of improved forage.

A new approach, drawing on leads from the first effort, was launched in 1957. Since clean cultivation in two of the earlier plantations apparently increased height growth of planted trees, and considerable damage can be expected while trees are small, frequent cultivation was prescribed as a means of increasing growth rate until trees reach a size that can tolerate grazing before we attempt to re-establish the pasture grasses. Accordingly, all plantations were completely renovated and new pine seedlings planted in January 1957 at the spacings used before, namely, 12 x 12 feet and 20 x 20 feet; and the trees were cultivated during the 1957 and 1958 growing seasons.

This treatment obviously has been effective in speeding growth of the slash pine. Cultivated trees averaged 22 inches in height after the first year and 61 inches at the end of the second (1958) growing season. Comparatively, this was about twice the height

Figure 23.—Clean-cultivated slash pine plantation used to test the effectiveness of fertilizer applications on height growth, Alapaha Experimental Forest, Ga.

growth made by uncultivated trees in the initial plantings in 1955.

Study plans call for cultivating the plantations again in 1959, for applying fertilizer and planting the pasture grasses in February 1960, and for turning the cattle in the following June. By that time, tree height should average more than 8 feet, new shoot growth will have hardened off, and forage species will have made considerable growth.

Effect of fertilizer is also being studied in an auxiliary Alapaha experiment started in 1957 (fig. 23). Some 1,150 slash pines spaced 10 x 10 feet were planted in 120 plots receiving applications of all combinations of nitrogen, superphosphate, and potash at 0-1-2 levels, or a total of 27 separate treatments. Rates of nitrogen application were 0, 100, and 200 pounds per acre; and the phosphate and potash rates were 0, 50, and 100 pounds per acre. All plots have been clean cultivated periodically to control competing vegetation.

It is too early for conclusions, tentative or otherwise; but some of the fertilizer applications have given good early response (fig. 24).

With more knowledge of nutrient requirements and the probable response to fertilization on representative timber sites, it may become economically feasible to increase the yields of slash pine by fertilization. Growing slash pine in south Georgia to a height of 10 feet or more in 3 years or less would not only increase total yields but would shorten the time needed before the first commercial thinning could be made. If the plantations are grazed, trees of this size ought to be able to withstand much of the serious damage from cattle grazing. However, fast growth or other induced responses may make the trees more susceptible to insect and disease attacks or create troublesome management problems. Already this plantation has a considerable incidence of *Dioryctria amatella* and rust canker (*Cronartium fusiforme*), as well as a heavy infestation of Nantucket pine moth (*Rhyacionia frustrana* (Comst.)).

In evaluating study results of this and similar studies, the economic returns from forage and timber products will be key elements. In the meantime, the Alapaha study and the management problems it poses will interest many landowners in the Southeast who are trying to get a greater financial return from piney woods holdings.

Figure 24.—Vigorous 2-year-old slash pine on clean-cultivated test plot fertilized with superphosphate at the rate of 50 pounds per acre.

First-Year Results from Rates-of-Stocking Study in South Florida

The year marked the start of a major study of rates of stocking cattle on cutover pine forest rangelands in south Florida. After a 2-year calibration period, cattle were turned into pastures on the Caloosa Experimental Range near Fort Myers under three intensities of stocking on January 10, 1958 (fig. 25).

The rates study is a first phase of the Forest Service cooperative range research program in south Florida. It will provide much-needed information on proper stocking to obtain best returns from cattle grazing use of native range. Other important work has been started to find practical ways of raising trees and cattle together on forest rangelands where year-round grazing is practiced. One such study deals with measurement of damage to planted slash pine and longleaf seedlings, sustained under the three intensities of cattle stocking used in the Caloosa rates study.

Figure 25.—Cows graze cutover pine range yearlong in the rates-of-stocking study started in 1958 on the Caloosa Experimental Range in south Florida.

In the Caloosa rates study, animal stocking is adjusted to produce three levels of herbage utilization of pineland threeawn (wiregrass) in the first grazing period after ranges are burned to freshen the forage. Pineland threeawn was chosen as an index to utilization because it comprises over 70 percent (by weight) of vegetative regrowth on burns during the first grazing period. Stocking levels and corresponding degrees of utilization are: *high*, 65 to 75 percent; *medium*, 45 to 55 percent; and *low*, 30 to 40 percent. Accordingly, cattle stocking is adjusted on range units as needed to meet the desired utilization levels.

Since forage grows back rapidly during the winter grazing period after burning, the range is sampled at intervals of about 20 days. With the data obtained, curves of progressive forage utilization are plotted to ascertain trends and to calculate adjustments in stocking rates. For all other grazing periods, the range is sampled at the beginning and end. In addition, ranges grazed for 90 days are also sampled at about the middle of the grazing period to get some measure of regrowth following grazing. By using a system of caged and uncaged plots, total herbage production is determined. From these data, quantity of herbage utilized during a grazing period can be readily calculated.

In 1958, the recovery of herbage following range burning was retarded by cold winter weather. For example, 20 days after cattle were turned onto freshly-burned ranges, the total ungrazed production of pineland threeawn ranged from 29 to 47 pounds per acre, ovendry. At the end of the grazing period in late March, production from plots caged against grazing from the time of burning yielded on an average from 132 to 204 pounds of herbage, per acre, ovendry. Because of this slow recovery, cattle required an abnormally large amount of supplemental winter feed. Because of low herbage production, utilization was higher than desired, even though some cattle were removed to lighten stocking. Average utilization of pineland threeawn was about 58 percent in units stocked at the low rate, 59 percent for the medium, and 71 percent for the high rate of stocking.

Differences in first-year calf production weights, though not entirely due to rate of stocking, were interesting. Calves from herds in range units stocked at low intensity averaged 45 pounds heavier at weaning time than those from herds in units stocked at the high rate. Calf grade on foot at weaning time also seemed to be related to stocking rate, since calves from units stocked at high intensity graded lower than those from pastures stocked at medium and low rates.

FOREST ECONOMICS

Activities in the Division of Forest Economics Research included continuing progress on the Forest Survey, completion of the latest annual surveys of pulpwood production and prices, and work on five special investigations. Some of these projects produced reportable results during the year; others are not far enough along.

Forest Survey work has accelerated considerably during recent years, in spite of the fact that more information is being collected. At the present rate, the cycle of surveys for the five states should be completed in 7 to 8 years (fig. 26). Splendid cooperation from forest industries, the states, and other Federal agencies is largely responsible for the faster progress.

Forest Survey crews completed the third periodic survey of South Carolina and moved into Florida on July 1 (also for the third time). By the year's end they had completed field work in the northwestern portion

Figure 26.—A two-man Forest Survey crew taking measurements on a variable-radius sample plot in Florida.

and reached the half-way point in the northeast (fig. 27). Timber inventory, growth, and cut computations for South Carolina are nearing completion.

This past year we again cooperated with the Southern Forest Experiment Station and the Southern Pulpwood Conservation Association on an annual survey of pulpwood production.

The business recession of 1957 reduced pulpwood production in the Southeast to 10.6 million cords, 4.7 percent below the all-time record level of 1956. However, only pine production actually declined; hardwood increased 8.6 percent to continue its long-term upward trend. Foresters are watching this trend with interest, for it is relieving some of the pressure of pulp industry expansion on the already heavily cut pine and is creating a new market for the more abundant but less-sought-after hardwoods. Also significant from a conservation standpoint is the rapidly growing production of pulp chips from sawmill slabs and other plant residues. It has doubled nearly every year since 1953, and the 1957 output of 426,600 cord-equivalents was 121 percent above 1956.

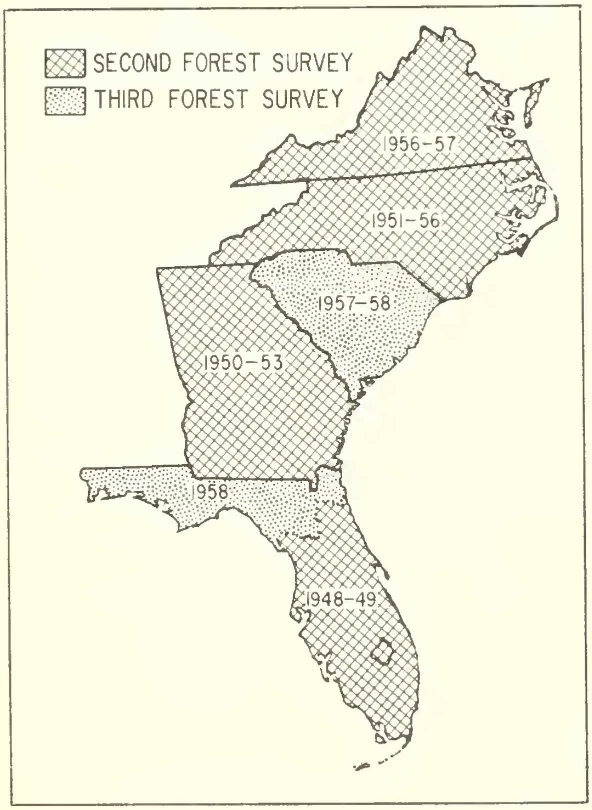


Figure 27.—Status of forest survey work in the Southeastern States.

During the pulpwood price survey, reports were obtained from 18 mills that consume about 70 percent of all the pulpwood and chipped residues produced in the Southeast. This survey revealed only slight changes in 1957 from the price pattern established in 1956. Rough pine pulpwood averaged about 5 cents per cord higher, hardwood about 15 cents lower, and these prices appear to have persisted through 1958. Including dealers' allowances, they are as follows:

PINE (per cord):	
F.o.b. railroad car	$15.20
Trucked to yard	15.40
Trucked to mill	16.35
Average price	15.50
HARDWOOD (per cord):	
F.o.b. railroad car	$12.65
Trucked to yard	12.70
Trucked to mill	13.75
Average price	13.35
PINE CHIPS (per ton):	
F.o.b. point of origin	$ 6.10

The special investigations consisted of four started the previous year and one new one. The former included studies of plantation costs and survival, an analysis of opportunities for new or expanded wood-using industries in an area, an attempt to develop a market valuation procedure for privately-owned tracts of marked sawtimber, and tests of new Forest Survey techniques adapted to use on variable-radius plots. The new investigation deals with the economics of forestry on farm and other small private holdings.

In the plantation cost and survival studies we have enjoyed the cooperation of Duke University, the Soil Conservation Service, the Virginia Division of Forestry, and the Champion Paper and Fibre Company. Efforts to date, in Virginia and South Carolina, have been devoted to exploring the effects of geographic location, soil, topography, existing vegetation, and other site characteristics on the cost of planting pine and on its rate of survival. These efforts are a first step in an attempt to develop a classification of planting sites useful in predicting the cost of and return from establishment and management of plantations.

The industrial development study is in an 8-county area of the North Carolina Piedmont. It is concerned with determining which species, sizes, and qualities of available timber are surplus to the needs of existing industries and whether it is feasible to base new or expanded industries on their ultilization. Most of the necessary field work has been completed, and analysis of the data is under way.

The timber valuation study, in cooperation with the South Carolina State Commission of Forestry, utilizes transaction records for pine sawtimber marked and cruised by Cooperative Forest Management foresters. The objective is to develop a method for appraising the market value of individual tracts.

Research on Forest Survey techniques involved methods of measuring stand density, the use of each tally tree as a sample tree, and development of volume estimating equations. Since July 1957, the Survey has employed variable-radius sample plots in the Southeast. According to this system, each diameter class of trees is tallied on a circular plot of different size, the size of plot being proportional to the size of the tree. The method has a number of advantages over conventional plots of fixed area but introduces complications in obtaining certain descriptive information. A case in point is the measurement of stocking and particularly the assignment of stand condition classes according to the proportions of area occupied by trees of varying merchantability and growth potential. The density study is aimed at developing better methods of obtaining this information.

Work on the problems of small ownerships began in June with surveys designed to explore the characteristics of small owners and their properties, ownership objectives, and the attitudes of owners toward the practice of forestry. Two areas were surveyed — one made up of 8 counties in the North Carolina Piedmont and the other a 9-county area in south Georgia. In each area, 100 small owners were interviewed and their woodlands examined.

A problem analysis to guide further small ownership studies is now being written. Some of these studies lend themselves to a regionwide approach and can be conducted by Asheville personnel; others must be more localized. An economist, recently employed and assigned to Charlottesville, Virginia, will soon undertake a rather intensive study of ownership problems in the Virginia Piedmont.

Trends in South Carolina Forest Area and Timber Volume

Preliminary results of the 1957-58 forest survey of South Carolina show a change of less than one percent in forest area since 1947. Forest area held its own at the expense of agricultural lands, in spite of considerable expansion in the use of lands for reservoirs, highways, suburban development, urban areas, etc. (table 1).

The rate of reduction in South Carolina's agricultural lands apparently is leveling off. Between 1936 and 1947 the area decreased more than 15 percent, but the decline for a similar period between the last two surveys was 6.5 percent.

Pine and pine-hardwood types still predominate in South Carolina, making up 54 percent of the commercial forest area. But both the 1947 and 1958 surveys showed strong shifts toward hardwoods (fig. 28). Pine and pine-hardwood types have decreased more than 1¼ million acres since 1936. Between 1947 and 1958 the decrease amounted to 840,000 acres, or 11.5 percent. Upland hardwoods have almost tripled in area since the original survey of 1936, and lowland hardwoods have increased more than one-third. Area in hardwood types expanded from 27 percent of the total in 1936, to 38 percent in 1947, and 46 percent in 1958.

Sawtimber volume in South Carolina declined almost 12 percent in the past 11 years. Yellow pines and soft hardwoods each decreased about 17 percent, the changes

Table 1.—Comparison of land use in South Carolina, 1947 and 1958

Use class	Area 1947	Area 1958	Change	
	-- Thousand acres --		Thousand acres	Percent
Forest land	11,942.6	12,015.8	+73.2	+0.6
Agricultural land	6,424.3	6,007.3	-417.0	-6.5
Other land	961.1	1,200.3	+239.2	+24.9
All land	19,328.0	19,223.4	-104.6	-0.5
Water	547.2	651.8	+104.6	+19.1
All classes	19,875.2	19,875.2	0	0

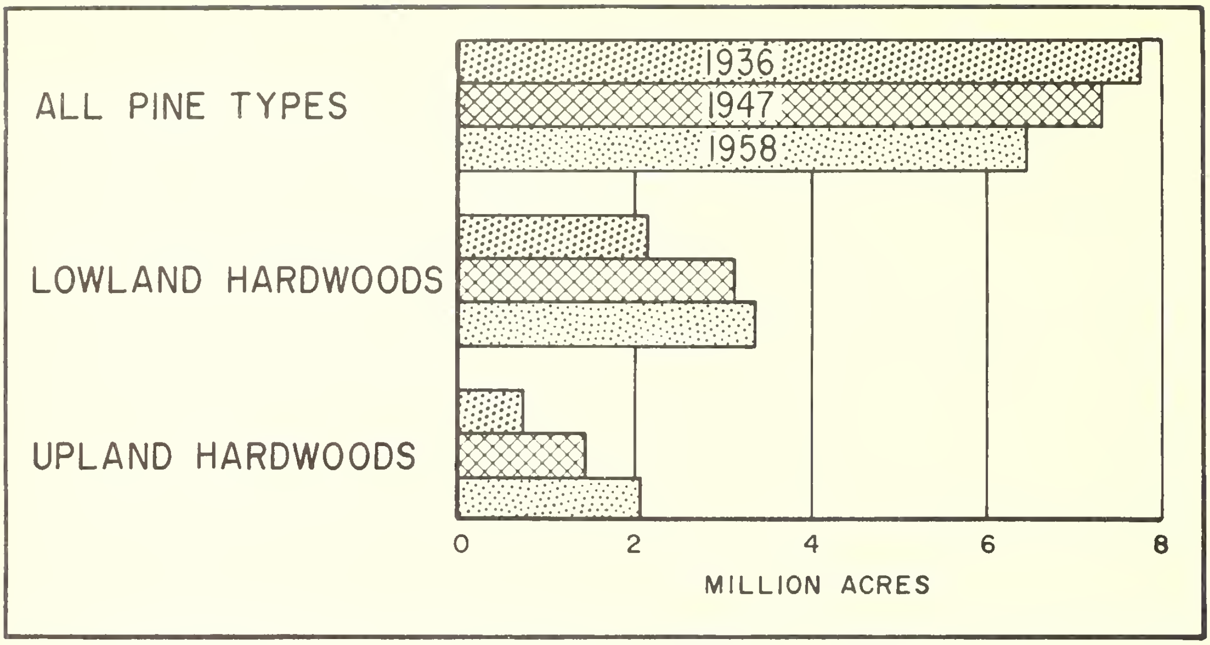


Figure 28.—Pine types in South Carolina have steadily given way to hardwoods.

amounting to 2 2/3 billion and 1½ billion board-feet respectively (table 2). Other softwood sawtimber increased by 13 percent and hard hardwoods advanced 9 percent in volume since 1947.

A reduction of 5 percent also occurred in cubic-foot volume of growing stock. Decreases of 400 million cubic feet in yellow pines and 280 million in soft hardwoods were only partially balanced by a 220-million cubic-foot increase in hard hardwood growing stock (table 3).

Net volume in cull trees has increased with each resurvey. Between 1936 and 1947 cull-tree volumes advanced 6 percent, but the next 11-year period showed a jump of 56 percent. Cull trees, especially large hardwoods, tend to accumulate in stands because timber operators pass them by and leave them uncut.

Table 2.—Comparison of sawtimber volume in South Carolina for three surveys

Species group	Year of survey 1936	1947	1958
	- - Million board feet - -		
Yellow pines	16,016	15,593	12,932
Other softwoods	1,801	1,511	1,705
Soft hardwoods	8,861	8,695	7,214
Hard hardwoods	3,903	4,343	4,755
All species	30,581	30,142	26,606

Figure 29 compares the net cubic-foot volume of all live trees, including those of sound and cull quality, for the three forest surveys. Softwood volume increased through the 16-inch diameter class between 1936 and 1947, but between 1947 and 1958 volumes increased only through the 10-inch class. During both periods rather uniform decreases in softwood volume occurred in the larger tree sizes. In the case of hardwoods, the volume change for each period between surveys was similar, increasing below the 18-inch class, but changing rather little in the larger diameters.

New Forest Survey Techniques Developed

Use of the variable plot in gathering Forest Survey data has made it feasible to adopt several other improvements in survey methods. The number of trees tallied on each plot has been reduced to the point where detailed measurements and observations can be taken for each tree tallied without excessive cost, thus making each a "sample tree."

Table 3.—Comparison of cubic-foot volumes in South Carolina for three surveys

Class of material and year of survey	Species group				All species
	Yellow pines	Other softwoods	Soft hardwoods	Hard hardwoods	
	Million cubic feet				
Growing stock:					
1936	4,196	408	2,564	1,168	8,336
1947	4,335	390	2,667	1,436	8,828
1958	3,934	397	2,386	1,658	8,375
Cull trees:					
1936	79	33	425	539	1,076
1947	131	32	531	444	1,138
1958	317	38	765	655	1,775
All live trees:					
1936	4,275	441	2,989	1,707	9,412
1947	4,466	422	3,198	1,880	9,966
1958	4,251	435	3,151	2,313	10,150

Previously, a subsample of tally trees had to be used to obtain detailed information.

The value of sample tree information was increased with the start of the present survey of Florida by abandoning the use of local volume tables based on average tree dimensions over wide areas, and average cull deductions and log grades based on special studies. Now each tree of volume size is measured for merchantable length, diameter, and growth; its cull volume is computed in board-feet and cubic feet; and each sawtimber tree is graded. Also, each tree is classified as to its position in the stand and its present or potential utility. Newly developed volume estimating equations adapted to IBM computation are then used to determine net volume and growth of each tree. These equations are sensitive to one foot of change in height and one-tenth inch change in diameter. The possibilities for analysis of the resulting data are broader and more meaningful, since each sample tree carries its own descriptive classifications and its own volume and growth instead of averages that tend to level out and obliterate information that might otherwise prove to be important.

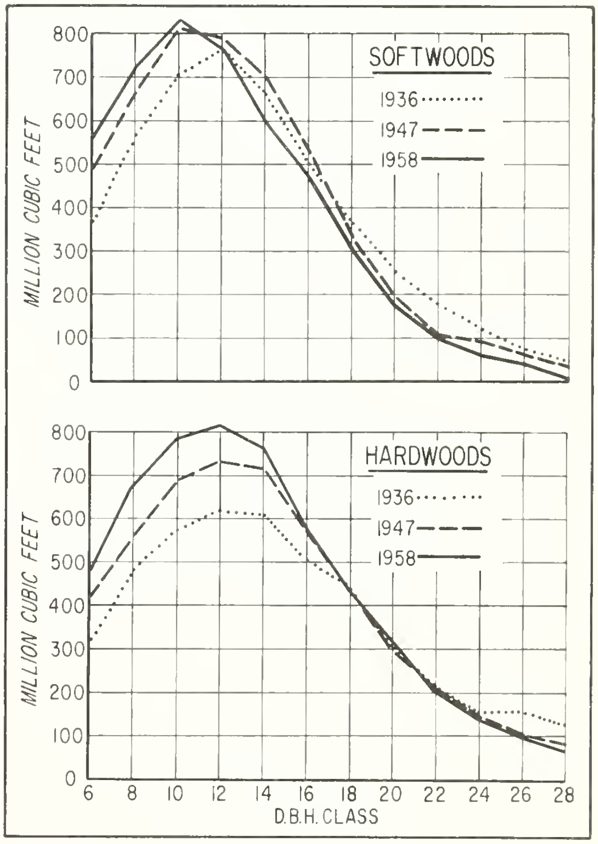


Figure 29.—Total cubic-foot volume has increased most in medium and small hardwoods and decreased most in medium and large softwoods.

A Simple Method of Appraising the Market Value of Pine Sawtimber

The principal use of timber appraisals is in making stumpage sales. Additional needs for appraisals are in determining loan values, settling estates, comparing the results of management systems on research forests, and similar purposes.

Even though the timber market is unorganized, it is relatively easy to find the approximate average price in an area merely by compiling prices received for recent sales. But timber characteristics differ so widely from tract to tract that the "going price" alone would not tell how much a particular lot of stumpage should bring. And on small forests, appraisal methods based on gross returns, manufacturing costs, and profit allowance are too cumbersome to use. However, a simple method of appraising the market value of particular tracts of marked and cruised pine sawtimber relative to the general average price is the result of a current study.

The market value of stumpage is determined largely by the worth of the product it will yield, the cost of converting it to that product, and the competitive condition of the stumpage market. Although stumpage price is also affected by the personalities involved in the transactions, price is the best estimate of "intrinsic" market value. In this study, 20 factors were tested for association with stumpage price. One measured intensity of competition, and another geographic location. Others were believed to influence logging costs, sawing costs, hauling costs, and the value yield of lumber. The data used were taken from 95 sales reported by project foresters to the South Carolina State Commission of Forestry.

Four variables significantly influenced stumpage price. Two of these were stand characteristics — average volume per tree and distance from the tract to the nearest stationary sawmill or concentration yard. The intensity of competition for the timber as measured by the number of bids received also had an influence. Furthermore, price varied geographically from lowest in the upper Piedmont to highest in the lower coastal plain. The independent influence of each factor on the price per thousand board-feet is shown in figure 30. The effect of the average volume per tree on price depended upon the general price level. That is, the premium paid for tracts containing larger-than-average trees is greater when the general price level was high than when it was low. Each additional mile from the mill reduced the price by 13 cents, while each additional bid raised it by $1.25.

Together, these factors accounted for nearly 60 percent of the price variation. The remainder could not be explained for at least two reasons. First, there were no measures

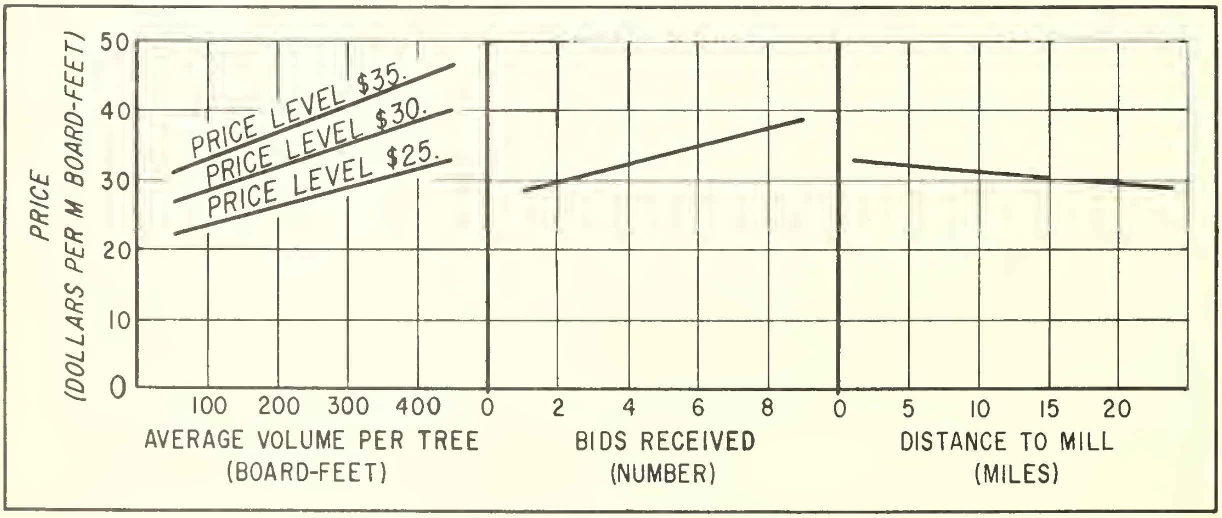


Figure 30.—Independent effect of each factor influencing pine sawtimber price in South Carolina.

of some potentially important factors, such as timber quality and difficulty of the logging chance. But perhaps more important, external factors, such as the relative strength of the positions from which sellers and buyers bargained, caused actual sale prices to deviate from the market values.

This study showed that while periodic price reports can relieve appraisers of the chore of determining the current stumpage price level, an average price in itself is of little value. Some means must also be provided for finding the market value of a particular tract. It was demonstrated in this study that such a procedure is feasible.

The Small Forest Landowner in Two Areas of the Southeast

Nothing in American forestry is of greater concern than the low level of productivity on the Nation's farm and other small private forest holdings. According to *Timber Resources for America's Future,* this problem is especially critical in the South. It further points out that increasing the growth on these lands is the only way to insure adequate future timber supplies. Forest industry and public forests alone lack the capacity to sustain the expected demand for wood.

To find out the characteristics of small forest landowners in the Southeast and what their attitudes were toward growing timber and toward public forestry programs, a random sample of owners was picked in two contrasting areas. These owners were interviewed and their properties examined. One area studied was in the coastal plain of Georgia; the other in the Piedmont of North Carolina. They were approximately equal in size and in area of forest land. The Georgia area was predominantly agricultural, with large, relatively prosperous farms. The few industries were small and oriented primarily toward agriculture and forestry. Forest products markets were well developed. By comparison, the North Carolina area was a rapidly industrializing area. Although the rural population was large, a substantial proportion of these people did not live on farms. The farms in general were small, and off-farm employment was important. The average forest property was also small — only half the size of the average in Georgia. As would be expected, the dollar income from forest products here was less than half that in Georgia.

The characteristics and attitudes of small forest owners in these two areas are summarized in figure 31.

Concepts of timber-growing varied widely among owners who claimed to be growing timber. To some it meant merely making an occasional timber sale. To others it meant refraining from cutting altogether. And conflicting uses, such as heavy grazing, frequently went unrecognized. Owners who were not actively growing timber by practicing forestry often felt that the required investment was beyond their means or that too long an interval would elapse before they received any returns. An additional number of Georgia owners considered their forest uneconomic, either because of its size or the character of the timber. Some North Carolina forests occupied potential industrial or residential sites, so speculative values precluded the practice of forestry.

In both areas free public forestry services, low-cost planting stock, and incentive payments for following specified forestry practices were available. The larger owners were usually the ones active in these programs. and those who joined in one program frequently participated in another. One reason commonly given by owners for not accepting forestry services or planting stock was that they could derive no benefits from the program. In the case of incentive payments, many owners either did not know they were available or were unable to fulfill the requirements. Few owners were unsympathetic with public forestry programs.

The results of this ownership survey indicated some of the major problems and opportunities of inducing this group of owners to practice forestry. For instance, judging by the ages at which owners acquire and relinquish title to land, present owners on the average cannot look forward to owning their forest land more than another 15 to 20 years. This would be unimportant if woodland normally remained in the family from generation to generation. But in about two-thirds of the cases it will be sold as part of a farm property. Because buyers have only a secondary interest in woodland, more money may be realized by selling timber and land separately. Thus, a major task in solving the small forest problem will be motivating owners to improve their forests while reducing incentives to liquidate their timber.

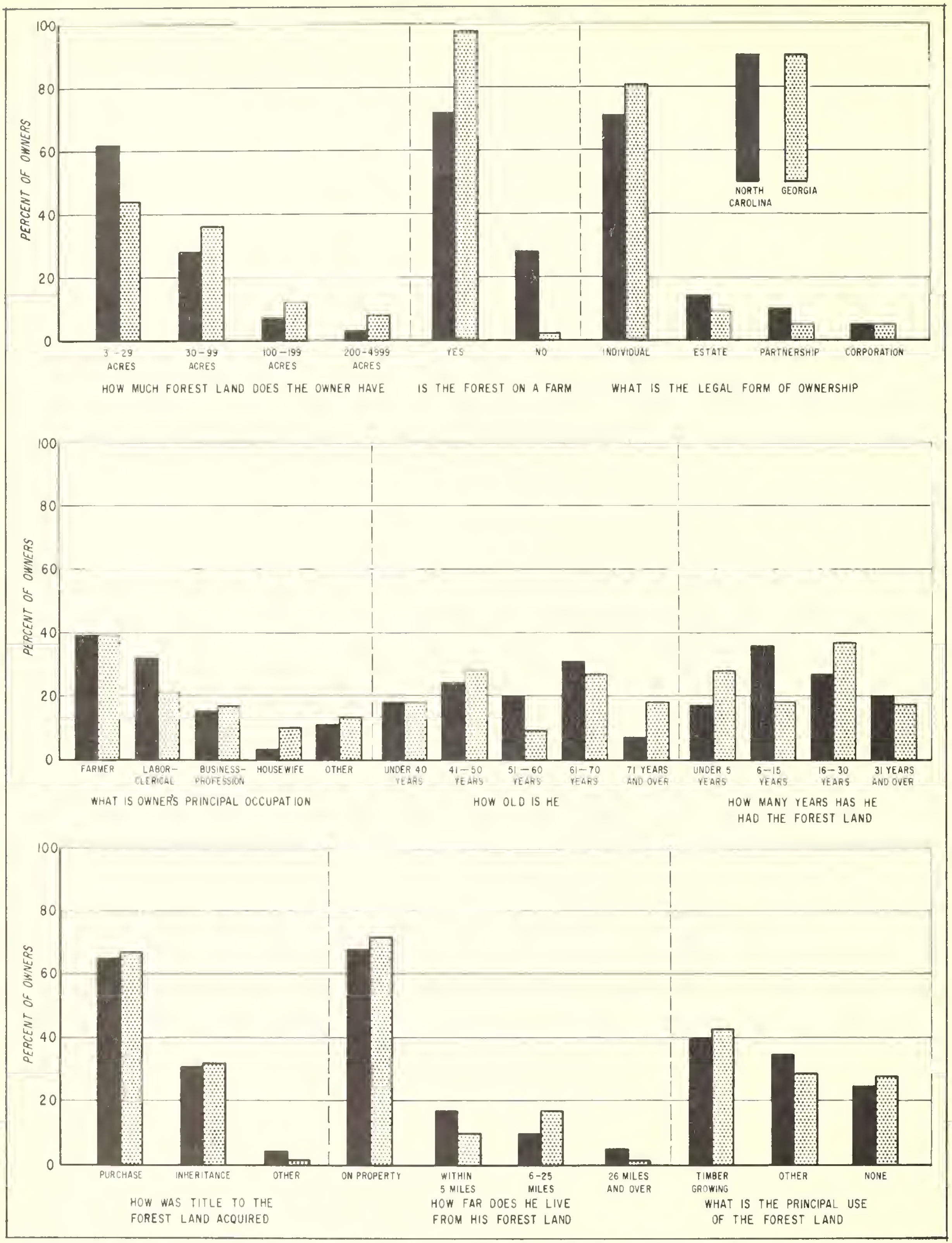
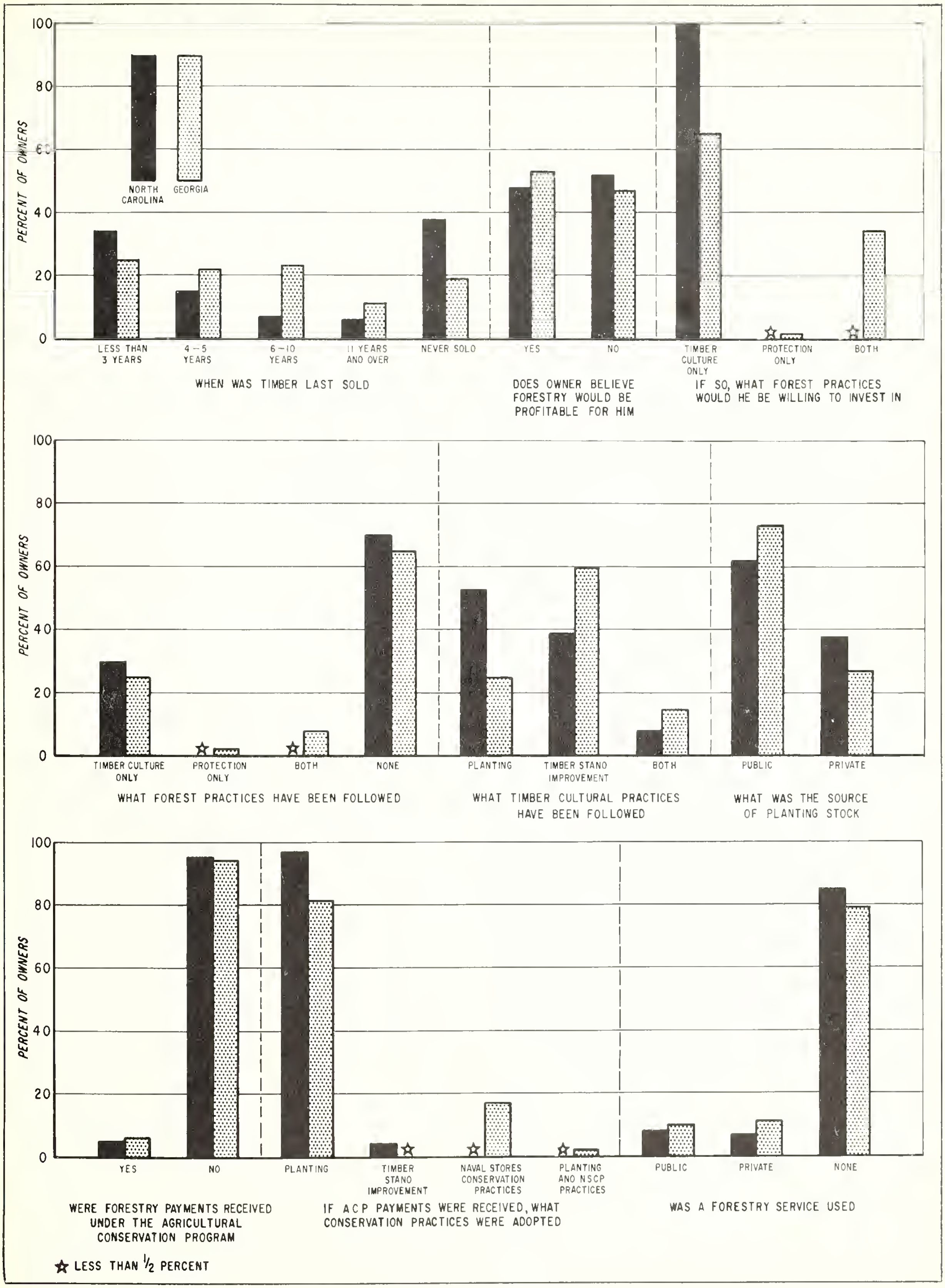


Figure 31.—Characteristics of small forest landowners and their attitudes toward forestry and toward forestry assistance programs.


PERCENT OF OWNERS
NORTH CAROLINA
GEORGIA
LESS THAN 3 YEARS
4 – 5 YEARS
6 – 10 YEARS
11 YEARS AND OVER
NEVER SOLD
YES
NO
TIMBER CULTURE ONLY
PROTECTION ONLY
BOTH
WHEN WAS TIMBER LAST SOLD
DOES OWNER BELIEVE FORESTRY WOULD BE PROFITABLE FOR HIM
IF SO, WHAT FOREST PRACTICES WOULD HE BE WILLING TO INVEST IN
TIMBER CULTURE ONLY
PROTECTION ONLY
BOTH
NONE
PLANTING
TIMBER STAND IMPROVEMENT
BOTH
PUBLIC
PRIVATE
WHAT FOREST PRACTICES HAVE BEEN FOLLOWED
WHAT TIMBER CULTURAL PRACTICES HAVE BEEN FOLLOWED
WHAT WAS THE SOURCE OF PLANTING STOCK
YES
NO
PLANTING
TIMBER STAND IMPROVEMENT
NAVAL STORES CONSERVATION PRACTICES
PLANTING AND NSCP PRACTICES
PUBLIC
PRIVATE
NONE
WERE FORESTRY PAYMENTS RECEIVED UNDER THE AGRICULTURAL CONSERVATION PROGRAM
IF ACP PAYMENTS WERE RECEIVED, WHAT CONSERVATION PRACTICES WERE ADOPTED
WAS A FORESTRY SERVICE USED
LESS THAN 1/2 PERCENT

FOREST INSECTS

The past year started out extremely cold and the low temperatures wiped out insect enemy number 1, the southern pine beetle, from the mountains. The epidemic, which had for 5 years demanded most of our attention, disappeared.

However, new problems soon appeared to take its place. The elm spanworm, spreading far beyond its previous range, demanded immediate study; a pine sawfly epidemic broke out in Virginia, North Carolina, and Florida; the balsam woolly aphid, notorious killer of fir in the Northeast and Northwest, revealed its potential as it killed a large number of Fraser fir near Mt. Mitchell, North Carolina, and threatened remaining stands. The more familiar insects, such as the bark beetles, the tip moth, pales weevil, and others continued to demand attention.

Figure 32.—A heavy infestation of balsam woolly aphid on the trunk of a Fraser fir.

Several personnel changes took place during the past year. Survey leader William McCambridge transferred to Albuquerque, and an assistant, William Carter, was called into the army for 3 years. Eben Osgood left his silvicultural control studies for advanced study at Minnesota. However, good replacements are gradually being added. Gene Amman of Fort Collins, Colorado, came into the research unit in August, and Robert Davis, now in medical entomology, will join him early in January. Harry Yates came to Macon from Duke to work in the nursery project; the tip moth is his major problem at present. Edward Merkel and Bernard Ebel are making good progress in their research on cone insects at Lake City, Florida.

Balsam Woolly Aphid

The balsam woolly aphid, *Chermes piceae,* related to destructive species in Europe, was discovered in the fall of 1957 on Fraser fir on the highest mountain in the Southern Appalachians. Aerial and ground surveys of the 7,000 acres of fir around Mt. Mitchell revealed that the aphid is distributed throughout the area; a large number of firs have already been killed, and more may be expected to die in the next year or two.

An infestation also exists near Skyland, Virginia, on the Blue Ridge Parkway, where the bracted balsam fir grows in mixture with Fraser fir; tree killing is not severe, but "gout" symptoms caused by aphid attack are common. To date the insect has not been detected in other Fraser fir areas in the Southern Appalachians.

Aphids attack the trunk and twigs of a tree and appear as specks of wax on the bark (fig. 32). When several million of these tiny insects feed on a tree through their needle-like mouthparts, they cause adverse changes in cells which affect translocation and lead to mortality.

In addition to the surveys already mentioned, aerial and ground checks of all fir stands are being continued. Tests of insecticidal control have been conducted to determine whether this method is feasible in areas which can be reached with ground spraying equipment. A pilot test is being planned to determine whether the aphid can be controlled by the application of insecticides in scenic areas. Methods of preventing spread of the aphid from infested to noninfested areas through quarantines are being explored. Cutting studies are being conducted to determine whether the spread of the aphid within and between infested areas can be controlled. Consideration is being given to the possibility of finding firs that are resistant to aphid attack. Basic to all these investigations, the life history and behavior of the insect in this area is being studied.

Elm Spanworm

The area infested by the elm spanworm in 1958 showed an increase of 270,000 acres over last year. The forests of northern Georgia, where the epidemic began in 1954, suffered less severe defoliation than in the previous year. The spread of the infestation since its initial detection is tabulated as follows:

	Area of defoliation	Damage
1954	Localized in small, scattered groups of trees	None apparent
1955	1,500 acres along the tops of the ridges	None apparent
1956	50,000 acres, principally along the tops of the ridges of northern Georgia	Some growth loss
1957	300,000 acres in Tennessee, North Carolina, and Georgia	Growth loss and dying of occasional trees
1958	570,000 acres in Tennessee, North Carolina, and Georgia	Growth loss and death of hundreds of trees defoliated for 2 or more years

Studies begun in 1957 to determine growth loss were continued this year. It was found that the trees most severely defoliated were growing only half their normal rate, while tulip poplar, which escapes defoliation, showed average or increased growth during the same period.

A study of the effect of last winter's low temperatures on the viability of elm spanworm eggs showed that the low temperatures had no effect on the viability of the eggs.

A pilot test was conducted in May to determine whether the insect could be controlled by airplane spraying of DDT. Six 50-acre plots (two plots at elevations of 1,700, 2,400, and 3,200 feet) were sprayed with one pound of DDT in 1 gallon of kerosene per acre to determine whether variation in foliage and insect development would influence the degree of control. Studies of the insecticidal effects (fig. 33) showed that the treatment was over 99 percent effective at the two higher elevations where the spray was applied during the earlier stages of insect and foliar development. Successful but somewhat less effective control was obtained in the lowest plots; the greater mass of foliage screened out the insecticide before it reached larvae feeding on the lower, protected leaves of the trees.

Pine Sawflies

In May an epidemic of pine sawflies, identified as the Virginia pine sawfly, *Neodiprion pratti pratti*, was detected on the Piedmont Plateau of North Carolina and Virginia (fig. 34). The epidemic ranged over some 400,000 acres, with about 130,000 acres of Virginia and shortleaf pines actually defoliated. Only one generation of these sawflies occurred, and feeding was completed prior to the emergence of the new foliage. No evidence of tree mortality has been observed. Committees to deal with the epidemic were formed soon after initial surveys were made. As a result, sampling plans have been developed for conducting egg surveys early in 1959 in both States. A control program will be drawn up if surveys show that another epidemic may develop.

During May in Taylor County, Florida, local feeding on loblolly pine by a sawfly identified as *Neodiprion exitans* was observed. By October two additional generations had occurred and defoliation had encompassed approximately 300,000 acres of loblolly pine forests in west-central Florida.

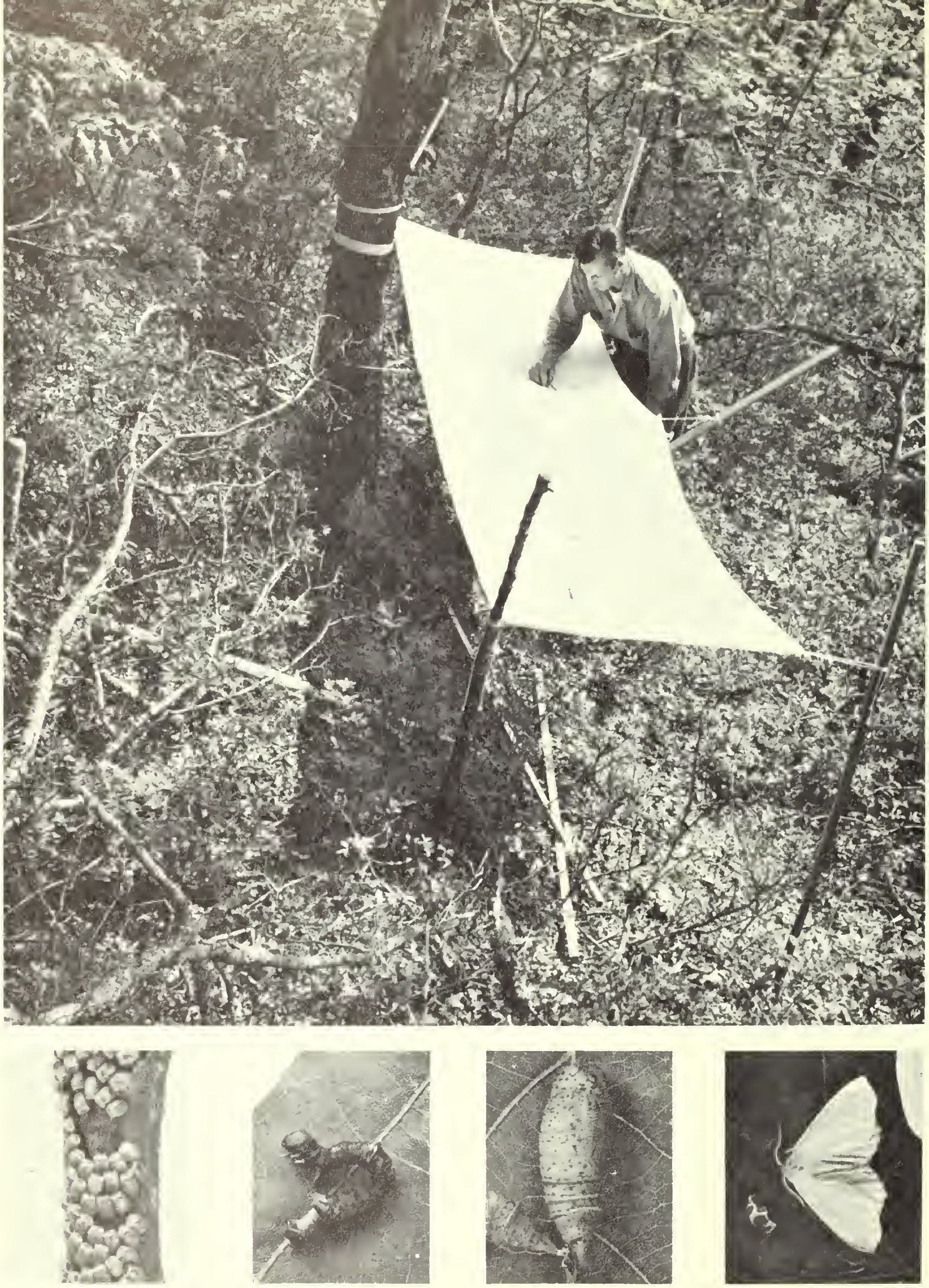


Figure 33.—Cloth tray beneath crown to catch sample larval mortality population. Inserts show, left to right, eggs, larva, pupa, and adult of the elm spanworm.

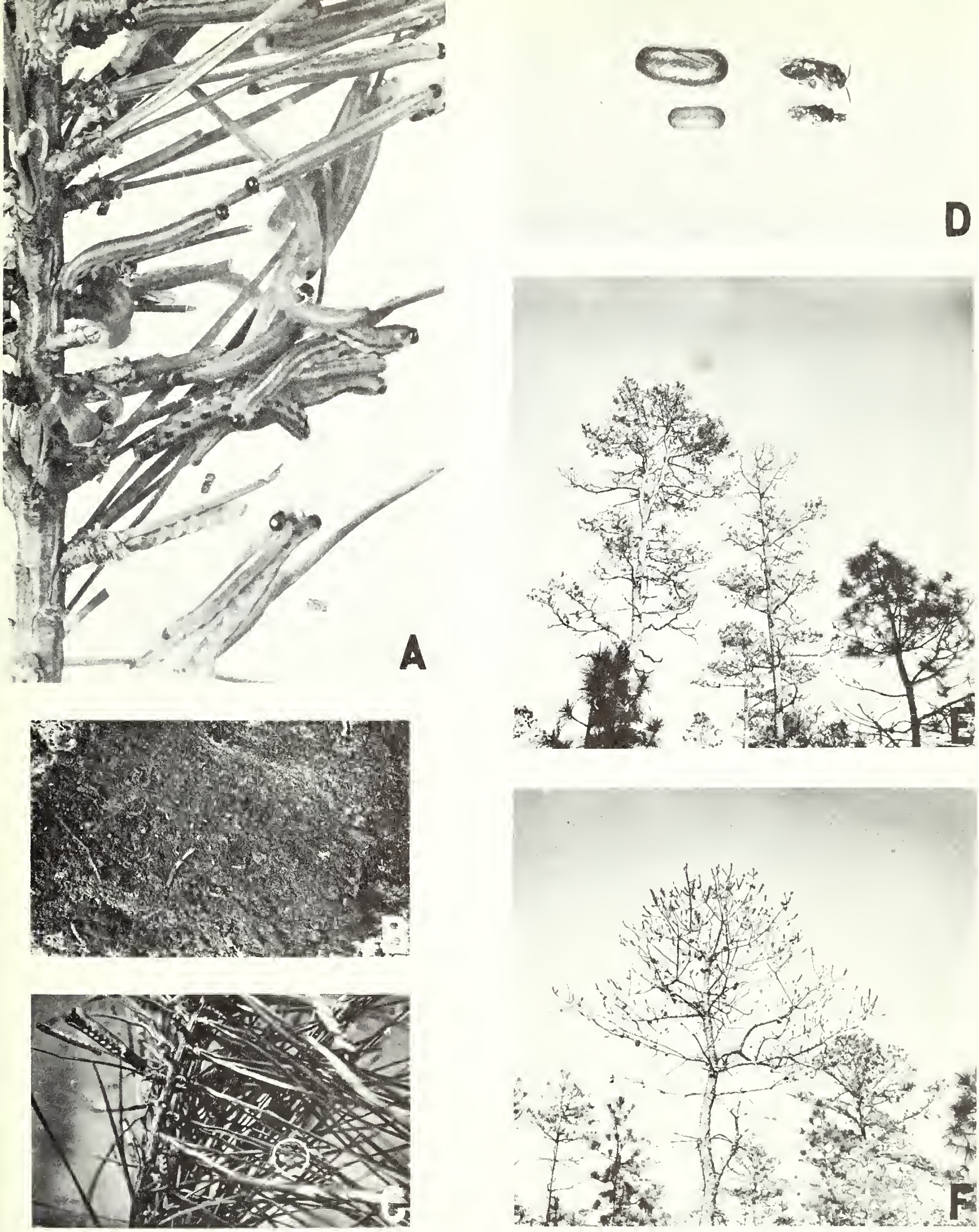


Figure 34.—Sawflies defoliated thousands of acres of pine in Virginia, North Carolina, and Florida. A, Mature larvae feeding on pine needles. B, Cocoons are spun in the soil. C, A cocoon attached to needles. D, Cocoons and adult sawflies; the female sawfly is larger. E, Sawfly defoliation of pine. F, Some trees are completely stripped of needles prior to emergence of new growth in the spring.

At present it appears that a high predator population is developing, and investigations will be continued until it is determined whether or not control is necessary.

Nantucket Pine Tip Moth

During the past year considerable time has been devoted to the biology of the Nantucket pine tip moth in Georgia. Migration of the larvae has been found to be as much as 14 inches from the point where eggs were laid to the point where the larvae bore into the shoot. The first larval instar spends at least several days feeding on the outside of the tips and needles; whether later instars do so must be determined. This indicates that foliar sprays aimed at the larvae can be applied after eggs have hatched.

A number of systemic insecticides have been tested as foliar sprays in exploratory studies. Both guthion and systox proved considerably better than some chlorinated hydrocarbons. Although systemics presently have certain limitations, they appear to offer considerable promise in the development of a successful method of tip moth control.

Aerial spraying of a seed orchard for tip moth control was conducted. Under the conditions of the test, DDT applied in dosages as high as 5.3 pounds per acre failed to give as good control as that obtained from the application of a 2 percent DDT emulsion with a hydraulic sprayer in an adjacent area.

Seed Insects

Several species of Dipterous insects have been found breeding in seed testing germination trays at the Forest Service seed testing laboratory at Macon, Georgia (fig. 35). One species of fungus gnat, *Bradysia coprophila* (Lintn.), was found in great numbers feeding on the ungerminated red pine seeds of a test from Michigan. At least two other species of yet unidentified Diptera have been collected from germination tests. Although only certain seed lots seem to be affected, the possibility of local infestation exists. All affected seed lots have exhibited below average germination percentage, thus indicating that these insects might play a rather important role in the success of seed germination in the field.

Pales Weevil

During the past 4 years a series of dips, sprays, and dip plus granular treatments have been developed by this Station to protect seedlings from being killed by weevils on recently cutover pine lands. This year a study was made using ½-, 1-, and 2-percent concentrations of aldrin to determine whether lower concentrations of insecticide could be used for treatment. From an economic standpoint the added protection provided by the two higher concentrations of spray and granular material is offset by the increased cost of insecticide. However, in the case of the dip treatment, because very little material is used, the small additional cost of the 2-percent material over the lower concentrations is more than offset by the larger number of seedlings which survive.

Insects Destructive to Flowers, Cones, and Seeds of Pine

A study to determine the identity of insects which damage flowers, cones, and seeds of slash and longleaf pines began in 1958. Collections to date indicate that three species of *Dioryctria* cone moths are common and cause extensive damage. Other insects warranting further study are thrips on female flowers, two species of lepidopterous larvae plus xyelid sawfly larvae on male flowers, scale insects on first-year cone stalks, cecidomylid fly larvae in cones, and *Laspeyresia* spp. seedworms in cones.

Records of Dioryctria-caused damage to mature slash pine cones have been kept since 1956 for 10 trees in a seed production study on the Olustee Experimental Forest (table 4). An interesting feature of this data is the surprising uniformity in total cone yield for the three consecutive years. It should be noted that the table does not reveal damage by *Dioryctria* spp. to cones during their first year of development. Further research is needed to determine the total impact of insects from flowering through cone maturation.

Tests were started to determine the susceptibility of a destructive pine coneworm, *Dioryctria abietella* (D. & S.), to residual deposits of different insecticidal water emulsions. Larvae for the tests were obtained from continuous mass cultures of this species by special rearing techniques (fig. 36) developed over the past 2 years.

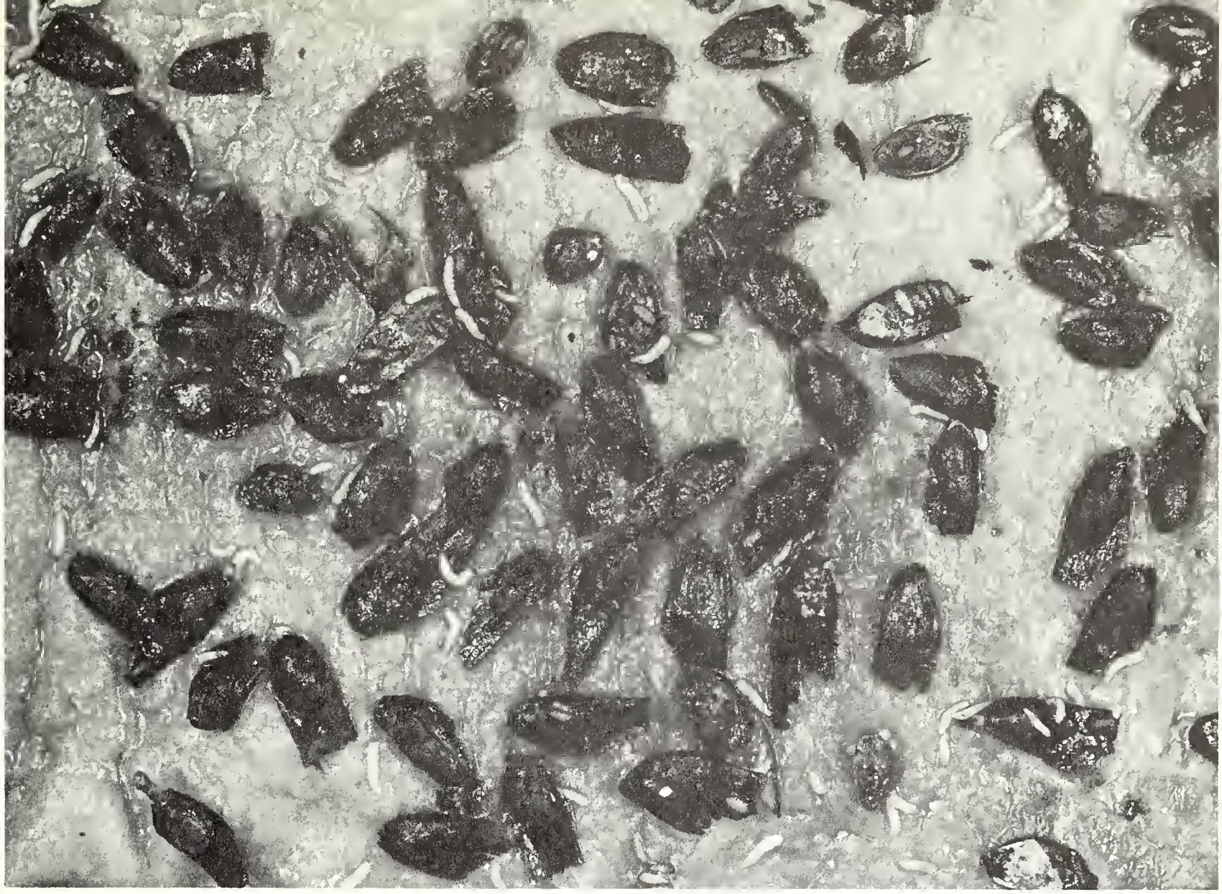


Figure 35.—Dipterous larvae and seeds of pine damaged by them.

Results of a preliminary study indicated that, on a given slash pine, second-year cones were more likely to be attacked by *Dioryctria* spp. larvae when they occurred on branchlets bearing first-year conelets infected by the southern cone rust disease. Conversely, the second-year cones showed a significantly lower incidence of coneworm attack when associated with healthy conelets.

Southern Pine Beetle

During the 1957-58 winter in the Southern Appalachians there were several periods in which subzero temperatures were recorded. Studies to determine extent of mortality to the overwintering broods of the southern pine beetles were made throughout the epidemic area. These studies revealed that in

Table 4.—Dioryctria damage in mature slash pine cones from 10 representative trees in a seed production area, Olustee Experimental Forest, Florida

Cone-damage classification	1956 cone crop		1957 cone crop		1958 cone crop	
	Number	Percent	Number	Percent	Number	Percent
Sound	1,500	56	2,443	88	2,167	77
Partially damaged	654	24	234	8	277	10
Completely destroyed	542	20	103	4	353	13
Total	2,696	100	2,780	100	2,797	100

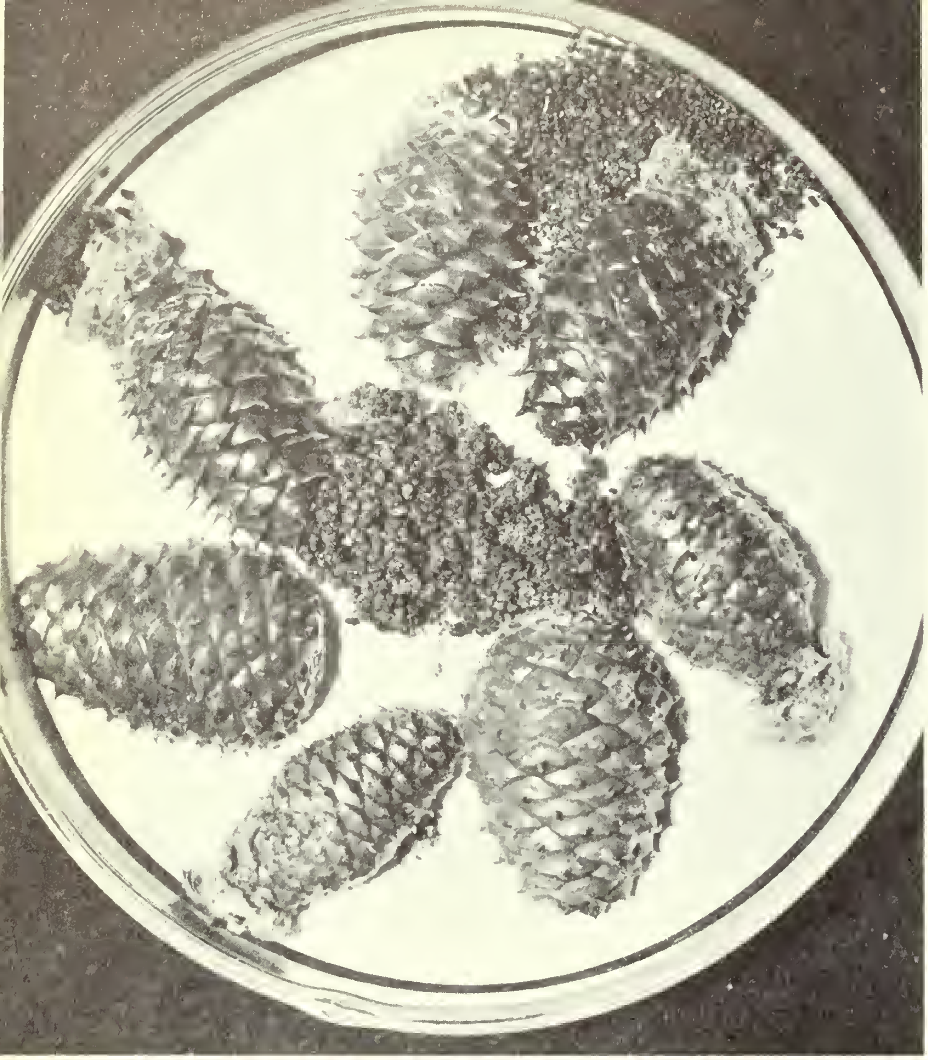


Figure 36.—Petri dish rearing container used in the mass culture of Dioryctria abietella larvae for insecticide screening tests. Note waxed slash pine conelets used for larval food, and frass pushed out of conelets by boring larvae.

all infested areas between 95 and 100 percent of the hibernating stages, except the egg stage, had been killed. (The egg stage makes up a small part of the overwintering population.) The effects of these temperatures on the predatory clerid beetle were also observed, and it was found that its populations were reduced only 40 percent. The feeding activities of these beetles, plus other natural control factors, were expected to reduce southern pine beetle populations to a negligible level.

On the basis of the above findings, the chemical control program which has been in progress for several years was halted. Aerial surveys of infestation areas and ground checks continued until fall. No active outbreaks were detected or reported from the epidemic area.

Southern pine beetle activity on private lands in eastern North Carolina was reported during early June. Aerial surveys in June, September, and December revealed the presence of 450, 800, and 200 fading trees respectively. These data, together with information gained from ground examinations, showed that the outbreak had definitely subsided by December. It appears that the epidemic will be at a very low level in 1959.

Black Turpentine Beetle

Attacks in the spring by the black turpentine beetle in stumps and uninjured pines in logging areas in the Southern Appalachians were reported to have been more frequent than in previous years. Although infestations had been fairly heavy in western North Carolina, this condition existed for only a short period and no chemical control was required. Throughout 1958, virtually no attacks by the beetle occurred on the coastal plain from Virginia to Florida.

FOREST DISEASES

This Division has been going through an orderly process of evolution and wears quite a different face than it did 5 years ago. At that time we were still working out the cause of littleleaf, we were just coming to grips with oak wilt, and nursery diseases were taking a heavy toll, unchecked, in several states. No one seemed to care about cone rust, and white pine blight and annosus root rot raised few foresters' blood pressure.

Today the littleleaf picture is far clearer to us, and we are well along on a program of breeding for resistance (fig. 37). Oak wilt is firmly entrenched as far south as southern North Carolina and Tennessee, but control measures developed by timely research show promise of keeping losses low. Two new men are off to a good start in cone rust control, stimulated by the huge toll the rust takes of the slash pine cone crop in Florida. One man devotes his main effort to the complex known as white pine blight — a spectacular littleleaf-like decline that is killing pines over a wide area in east Tennessee. Excellent control of nursery root rots has been achieved and put in practice, and two men are assigned to soil fumigation work and other nursery diseases, such as fusiform rust, chlorosis, cedar blight, et al. *Fomes annosus*, a fungus native to the U. S. and also the leading forest pathogen of Europe, is now showing its colors in our South, and heavy losses in many white and slash pine plantations have forced us into a major study of its behavior and control.

Our work is organized along three main lines — nursery diseases, forest diseases, and disease surveys. Pathologists are located at Asheville, Raleigh, Athens, Macon, and Lake City. Our staff, although not large, is strong and well balanced, with six Ph.D.s, two almost Ph.D.s, two Masters, and three other experienced men. Recent additions that we are confident will strengthen our work

Figure 37.—Shortleaf pine seed orchard at Athens, Georgia, composed of grafted selections from trees showing resistance to littleleaf and having other desirable characteristics. Grafts made in 1953. Each row is from scions from one selection. Note large difference in growth of different clones.

greatly are: Otis Maloy and Fred Matthews at Lake City, Charles Berry at Asheville, Charles Hodges at Raleigh, and Samuel Rowan at Macon.

Nursery Diseases

Black root rot of southern pines is now known to occur in at least eight coastal plain nurseries. Hodges had shown that it can be caused by species of Fusarium and Sclerotium that produce indolacetic acid during hot weather (fig. 38). Nematodes appear to have a secondary role in the disease. Fumigation tests continue to show superiority for methyl bromide over other materials tested. One field has produced four successive seedling crops free of root rot after one fumigation with methyl bromide.

Spraying for fusiform rust control only when weather conditions are conducive to spore dissemination and infection confirmed our earlier findings that "prescription" spraying can cut the number of applications by as much as two-thirds. Properly timed sprays, either by prescription or by fixed schedule, gave excellent rust control in 1958.

Damping-off is accentuated by cool weather during the first 2 weeks after planting, and by early application of nitrogen fertilizers to the seed beds.

Of 40 fungicides tried for control of Arizona cypress blight in Georgia, phenyl mercury dithiocarbamate was the most promising. All of the mercury compounds helped some, but none eliminated the disease. Phomopsis blight of redcedar in North Carolina was partially controlled with Semesan and with Kromad.

Cylindrocladium scoparium causes root rot and top disease in white pine and Fraser fir. Methyl bromide, applied before sowing, will check it effectively for one growing season. However, the disease can become very severe the second season after fumigation.

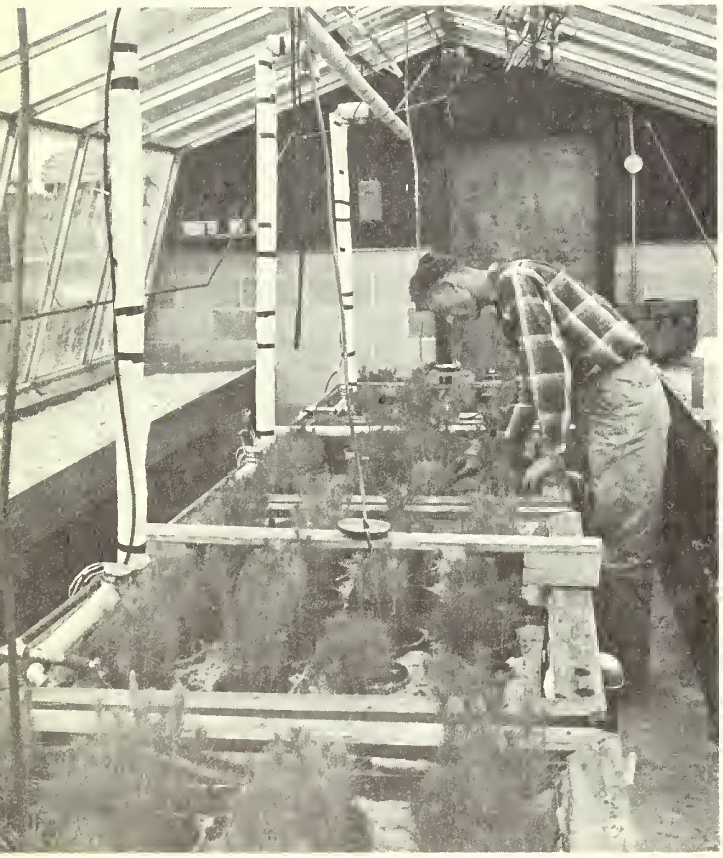


Figure 38.—Constant-temperature tanks at Macon, for the study of black root rot and chlorosis.

Cone Rust

A major destroyer of slash and longleaf pine cones is the rust caused by *Cronartium strobilinum* (fig. 39). New research aimed at direct control is under way. Slash pines were sprayed with ferbam, captan, Basi-cop, and Puratized Agricultural Spray (PAS) in an attempt to control damage by the rust. Only ferbam appeared to reduce rust incidence.

In another study, the four fungicides were tested individually on female flowers on 18 slash pines for control effectiveness and toxicity. Ferbam, captan, and Basi-cop did not harm the tender flowers, while PAS proved to be injurious. A low incidence of rust on the experimental area was noted after a wildfire along the windward side destroyed a heavy concentration of runner oak just prior to the time when flowers were receptive. This oak is one of the primary alternate hosts of the rust. This accidental "control" will be exploited in next year's studies to determine the effectiveness of control burning in preventing rust damage.

A third study tested the effect of the four fungicides on the germination of slash and longleaf pollen. Captan and Basi-cop markedly inhibited germination, and PAS proved to be lethal. Ferbam, however, stimulated germination beyond that of the untreated series.

Blister Rust Control

Mortality of white pine from blister rust continues a steady increase in a 2.5-acre unprotected (no ribes removed) study plot in Ashe County, North Carolina, indicating losses to be expected at the higher elevations (table 5).

Table 5.—White pine losses from blister rust in an unprotected area in North Carolina

Tree size, 1946	Trees observed	White pine mortality			
		1946	1950	1954	1958
	Number	- - -Percent - - -			
Over 10 feet high	117	1	4	8	11
1-10 feet high	34	0	15	38	38
Seedlings up to 1 foot high	100	0	2	12	25

Figure 39.—Cone rust on slash pine. Left, swollen, rusted, first-year cone. Right, normal, healthy, first-year cone.

Five new centers of infection on white pines were found in Ashe and Watauga Counties, North Carolina, and one in Johnson County, Tennessee. Severe losses had occurred at two small stands of young white pine in North Carolina where no ribes had been removed. Negligible damage was done at the Johnson County center, where ribes were removed. Aecial production during the spring was the heaviest on record in North Carolina.

Technical assistance was given the states of North Carolina and Tennessee in conducting pre- and post-planting examination of privately owned white pine plantations, ribes suppression work, and related activities. In North Carolina, plantings totaling approximately 76,000 trees were found exposed to blister rust infection from ribes growing nearby.

White Pine Blight

White pine blight is a disease or a complex of diseases that results in either dieback, shortening, or chlorosis of needles, or a combination of these symptoms (fig. 40). Many affected trees die. The cause is not definitely known, although the disease has been noted in the east for many years. The Station began a cooperative study with TVA, the Tennessee Division of Forestry, and the University of Tennessee in 1957. Although major attention is given the disease as it occurs in eastern Tennessee, it is also being followed in Virginia and West Virginia.

There was little change in the condition of blighted trees in West Virginia and Tennessee in 1958 compared with 1957. Because of the somewhat different symptoms, it is not yet clear whether the disease is the same in both areas.

Blighted pines have poorer root development and fewer living root tips (table 6), but as yet no pathogenic fungi have been isolated from the roots. Imbibitional water values of soils in blighted stands were lower than those of "healthy" soils, indicating that "blight" soils may not retain water as well.

Grafts of healthy shoots on diseased, diseased on healthy, and diseased on diseased twigs are under study. Also, blighted seedlings are being transplanted within and to areas outside of blight occurrence. The responses observed on these tests are expected to provide clues as to whether we are dealing with a pathogenic or a physiologic disease.

Figure 40.—White pine blight in Tennessee. Left, two blighted trees; center, blight-killed tree; right, healthy tree.

Table 6.—Living root tips on blighted and healthy pines

Locality	Stand condition	Month examined	Root tips living	
			Blighted trees	Healthy trees
			- - - -Percent- - - -	
Pocahontas County, West Virginia	Diseased	June	31	61
Pocahontas County, West Virginia	Diseased	June	33	51
Morgan County, Tennessee	Diseased	Sept.	20	39
Greene County, Tennessee	Healthy	Sept.	--	30

Fomes Annosus Root Rot

Fomes annosus has not been damaging in the Southeast until recently, except as a killer of redcedar. Now, however, cases of windthrow and outright killing of white pine in North Carolina and Virginia and slash pine in Georgia and South Carolina by *F. annosus* are causing concern (fig. 41).

Most of the stands with much root rot had previously been thinned. Thinning provides stumps in which the fungus builds up. Thinned plantations appear to be vulnerable because of the proximity of roots of individual trees, and because planting results in dead, strangled roots that serve as entrance points for fungus. Several instances of root rot have also occurred in thinned natural stands of white pine, however, so this is not strictly a plantation disease.

Site factors may be important, too, in favoring root rot. For example, the soils in three infected white pine stands were found to be more droughty than soils in nearby areas free of root rot.

The English stump-creosoting control method is under test in several newly thinned stands to see whether it reduces the incidence of root rot by preventing *F. annosus* from colonizing fresh stumps.

Mycorrhizae of Southern Pines

An investigation of the mycorrhizae of shortleaf, loblolly, slash, and longleaf pine is being made so that we can better understand the role they play in the nutrition of these species and determine their effect upon the resistance of the roots to attack by parasitic organisms.

A first step is the identity of the mycorrhiza-forming fungi. This is being done by growing seedlings aseptically (fig. 42), and inoculating the root medium with different suspected mycorrhizal fungi. Seedlings of the four species are being grown in association with over a dozen basidiomycetes, including such common mushroom-formers as *Clitocybe laccata*, *Amanita muscaria*, *Lepiota procera*, and *Boletus betula*.

Clitocybe laccata appears capable of synthesizing mycorrhizae when associated with roots of shortleaf, loblolly, slash, and longleaf pine; *Amanita muscaria* with roots of slash and loblolly pine; and *Lepiota procera* possibly with roots of shortleaf, loblolly, and slash pine.

Figure 41.—Fomes annosus root rot in a 31-year-old white pine plantation in North Carolina, thinned in 1948. The trees blown over are badly root rotted.

Figure 42.—A loblolly pine seedling grown aseptically from seed and later inoculated with a mycorrhizal fungus.

Oak Wilt

Data are now becoming available on the efficiency of the wilt control method in use in North Carolina and Tennessee. This method consists of felling only the wilting trees, poisoning the stumps with Ammate, and spraying the hole and limbs with a BHC-DDT-Penta mixture in fuel oil. Control efforts began in the North Carolina counties in 1954 and in Greene County, Tennessee, in 1955; no control has been in effect in Washington County, Tennessee. Table 7 shows the encouraging control results, judged by active new centers per 100 square miles of area in 1958, as compared with the situation before control was started.

To follow the wilt-spread pattern, 100 treated centers are scouted on the ground annually to a radius of 300 feet. In 1957 there was new wilt at 27 centers, and only 1 case occurred beyond 50 feet from a wilt tree. In 1958 there was new wilt at 32 centers and none was beyond 50 feet. This pattern suggests that we are controlling long-distance spread but not local spread. In the case of 9 active wilt trees near other wilt trees that yielded the fungus from the stump and roots, no infection via root graft was found after extensive root excavation. In the case of 12 others, the fungus could not be isolated at stump height. Thus, in most of these cases of local spread, root-graft transmission can be questioned.

An east-wide system of post-control appraisal, in which this Station has a part, has been started. Southern Appalachian plots are being established in treated areas in North Carolina and treated and untreated plots in Tennessee.

Defect in Piedmont Hardwoods

An extensive 3-state study of hardwood defects with regard to their abundance and seriousness has clearly shown that most trees approaching or just above minimum saw log size have so many minor defects, that, using the next poorest face of the butt log as the index, less than two percent of the combined butt log lengths would have yielded 2-foot clear cuttings.

Table 7.—New wilt centers in 1954 and 1958 in relation to treatment applied

County	Surrounding situation	Treated	New wilt centers per 100 sq. mi.	
			1954	1958
Buncombe and Haywood Counties, North Carolina	Little wilt around them	Yes	1.2	1.4
Greene County, Tennessee	Surrounded by "wilt counties"	Yes	1.2	4.5
Washington County, Tennessee	Surrounded by "wilt counties"	No	1.1	14.5

Considering each defect individually, knots and branching led the causes of degrade. Other small defects resulted from several insects, from birdpeck, and from scarring, and caused heavy quality losses because they were so numerous. Stem diseases, including rots, lead more to outright cull than defect; the same is true of sweep and crook.

A manuscript has been prepared on the study and gives much new information on defects, their extent, and stand factors related to defectiveness.

Search for Blight Resistance in Chestnut

Now that the blight has had ample time to "saturate" the chestnut population, any freedom from disease on the part of trees of pole size or larger might be expected to indicate true resistance. An intensive search is under way for such trees. About half of the many resistant cases reported have proved to be Asiatic species. Most of the rest proved unfit for testing because of blight or small size. A few trees with some promise have been found, and scions from them will be grafted to American and Chinese chestnut stocks this coming spring by TVA. The work is part of a joint project with this agency and the Northeastern Forest Experiment Station to try to discover and propagate resistant chestnuts.

Miscellaneous

Pitch streak is a disease of unknown cause in turpentined slash pine in south Georgia and Florida. In 1958 there was a reduction in both the intensity of the disease and in mortality of affected trees. Although additional cases have been found, the incidence of pitch streak appears to be leveling off. The disease is now thought to be strongly influenced by drought conditions. Thus, increased rainfall in pitch streak areas during the past several years is believed contributory to the reduced activity of the disease.

Oaks continue to die from unexplained causes in some areas, and systematic observations are now being made on plots in north Georgia to supplement the work of the Northeastern Station on this problem.

Diseases that were prominent in causing damage in 1958, other than those already discussed, included spot anthracnose and Ascochyta leaf spots of dogwood, Elsinoe leaf spot of oak, hemlock twig rust, and mimosa wilt. Reports of mimosa wilt have been received from widely scattered cities as far south as Gainesville, Florida.

FOREST MANAGEMENT

The forest management research program was strengthened in 1958 by the addition of new personnel, funds for the construction of new laboratories, and expansion and reorientation of portions of the program.

The expansion of seed production research made it possible to employ Dr. Robert L. Barnes, a plant physiologist exceptionally well qualified by education and experience. With the cooperation of Duke University, he is now stationed at the Botany Department, where excellent laboratories and outstanding technical counsel are available. Under the general supervision of our Lake City Research Center, Dr. Barnes will plan and conduct studies of the physiological and biochemical processes involved in the flowering and seed production of forest trees. These studies will include determination of the kinds and proportions of organic compounds in flower and vegetative buds throughout the period of bud differentiation and development, the factors affecting the proportions and concentrations of these compounds, and the critical levels of these compounds for bud differentiation. His first efforts are being directed at the physiology of flowering in slash pine.

Another plant physiologist, Dr. Mason Carter, has joined the Athens-Macon Research Center staff to help organize a seed research laboratory in conjunction with the regional Seed Testing Laboratory at Macon, Georgia. The purpose of the seed research laboratory is to make certain that the latest advances in plant physiology, biochemistry, and related sciences are brought to bear upon seed problems to insure the highest quality seed for the lowest cost. Dr. Carter will provide the specialized technical knowledge and skills necessary to develop and carry on an effective seed research program.

All phases of the research program at Lake City, Florida, will soon be housed in a new building on the Olustee Experimental Forest (fig. 43). The new building is designed as a research laboratory and administrative unit and will contain 8,700 square feet of air-

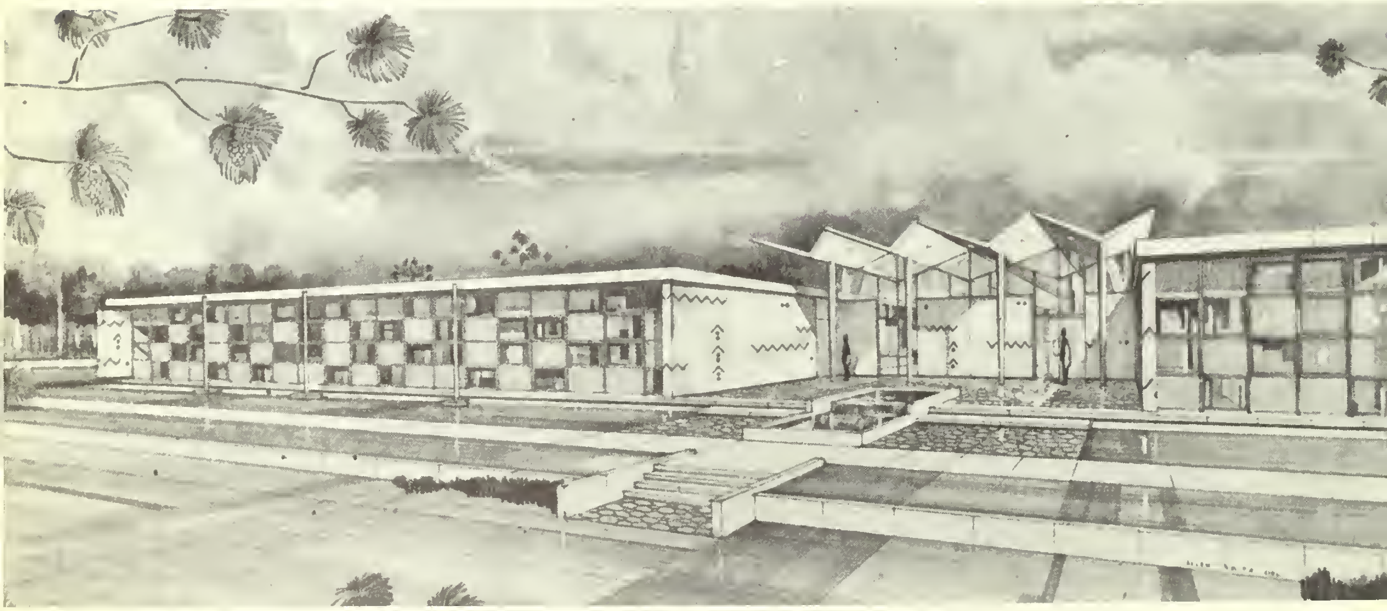


Figure 43.—Architect's drawing of office-laboratory planned for the Lake City, Florida, Research Center. The building is scheduled for completion in 1959 on the Olustee Experimental Forest.

conditioned space. The center of the building will have a utility core that will supply fume, dust, heat, and humidity control to the genetics, physiology, soils, pathology, and entomology laboratories grouped around it. The offices lining the outer walls will house a well-balanced research team under the supervision of Dr. Karl F. Wenger. The forest management research project is under the technical direction of Pieter E. Hoekstra, and the genetics and physiology research project is headed by Anthony E. Squillace. Mr. Squillace came to Lake City from the Intermountain Forest and Range Experiment Station, where he had spent a number of years selecting and breeding blister-rust-resistant and otherwise improved strains of western white pine.

The forest management research program in the Carolina Piedmont has been reoriented by shifting the supervision of the Hardwood Research Project at Statesville, North Carolina, from the Union Research Center to the Asheville Research Center. This move allows David F. Olson, Jr., to serve as project leader for forest management research in both mountain and Piedmont hardwoods. The move also permits Dr. Louis J. Metz, Research Center Leader at Union, to give regional direction to the Station's forest soils research program and to begin the development of a soils laboratory (fig. 44) that will serve the soils-site studies being conducted at all the station's research centers.

The establishment of a research unit at Charlottesville, Virginia, has enabled the Franklin Research Center to extend its program into the Piedmont and mountains of Virginia as well as the coastal plain of Virginia and North Carolina. The new unit, under technical leadership of Glenn P. Haney, will be concerned with both the silvicultural and economic problems of forest management. This dual character of the Charlottesville unit simply recognizes the fact that while silviculture and economics can be neatly pigeonholed on paper, they are inseparable on the ground. The small ownership problem deserves and will receive special consideration in the Charlottesville plans, since 90 percent of the forest land in the Virginia Piedmont is in small holdings. Although the intermingled industrial landowners have made great progress toward intensive management of their lands, the condition of these small holdings is about as poor as any in the United States. Since silviculture is not

Figure 44.—The Union soils laboratory is being modernized with new and more efficient soil testing equipment.

strongly affected by size of holding, it is obvious that the differences are in the economics of forest management. The Charlottesville unit will attempt to develop schedules of costs and returns for various types and intensities of forest management practices and then use this information to determine the place of forestry in the farm enterprise. The major lines of silvicultural research will be species-soils-site relationships and the management of shortleaf and Virginia pine.

In the coastal plain, the Charleston Research Center is starting a new program aimed at the management and improvement of wetland sites in South Carolina. Ralph Klawitter, the project leader, has prepared a project analysis to guide the forest and land management research in the swamps and bays of the coastal plain.

The following selected items of accomplishment illustrate our progress in older lines of research during the past year.

ARTIFICIAL REGENERATION

Forest tree planting in the South has reached one million acres a year and is still increasing. This program requires tremendous quantities of seed and planting stock, and heavy expenditures of money and manpower. The increase in area planted has been matched by the increased demand for better methods of producing seed and planting stock, preparing planting sites, and planting

Figure 45.—In 1953 all but the 33 best trees per acre were cut out of a 21-year-old slash pine stand to create a seed-production area. The remaining trees were 26-years old, averaged 14 inches in diameter, and averaged 77 feet in height in 1958.

trees or seed. While the bulk of the seed still comes from regular timber-producing stands and plantations, much of the seed in the future may come from seed-production areas and seed orchards. The main criterion of success in these stands will be the amount of good seed produced per acre per year.

Cone and Seed Production in a Slash Pine Stand

Because cone counts in pine are reasonably good indicators of the size of the seed crop, this relationship has been used in forecasts. While cone counts are useful and have been reliable over large areas, the technique can give poor estimates in a single stand. A 21-year-old natural slash pine stand near Olustee, Florida, was thinned in the fall of 1953 to establish a demonstration seed-production area (fig. 45). Total cone and seed production were measured on 10 trees beginning in 1956 — the first year that the effect of release on cone production could be expected. The 3-year cone and seed production was:

Year	*Cones* (*Bushels*)	*Seed* (*Pounds*)
1956	13.5	4.9
1957	13.9	17.2
1958	14.0	9.3

These variations in the cone-seed ratios in a seed-production area may be the results of insects, disease, or simply inadequate pollination in the poor years. Efforts are now being made to control insect and disease pests of cones and seeds, and it may be that studies designed to improve pollination will offer equal promise in insuring consistently high yields of seed.

Seed Testing

While most seed losses are caused by pests or climate long before the cones are collected, some of the most expensive losses occur in the nurseries when seeds fail to germinate. Both loblolly and slash pine seed may exhibit a dormancy that cannot be predicted on the basis of either appearance or geographic source. Paired germination tests of stratified and nonstratified samples at the regional Seed Testing Laboratory have confirmed the value of such tests prior to treatment of the entire lot of seed (table 8).

Table 8.—Effect of stratification upon the germination of loblolly and slash pine seed

Species and year tested	Seed lots tested	Effect of stratification: Benefitted	Injured	Unaffected
	Number	Percent	Percent	Percent
Slash pine:				
1956	26	15	35	50
1957	41	15	66	19
Average		15	54	31
Loblolly pine:				
1956	67	48	7	45
1957	74	65	9	26
Average		57	8	35

The most efficient use of seed requires a decision based upon individual lot characteristics. This decision can be made satisfactorily only after comparative tests of stratified and unstratified seed.

Planting Pines in the Carolina Sandhills

"Planting Pines in the Carolina Sandhills" by Robert D. Shipman, Station Paper 96, was published in 1958. This paper represents 4 years of intensive research by this Station, the South Carolina State Commission of Forestry, the Savannah River Project of the Atomic Energy Commission, the School of Forestry of North Carolina State College, the North Carolina State Department of Conservation and Development, and the Westvaco Experimental Forest of the West Virginia Pulp and Paper Company.

The most urgent problem in the Sandhills is survival — how to bring the land into timber production at a reasonable cost. After 4 years we have some of the answers, many of them partial, but with helpful leads. Good examples of the answers are the prescriptions for planting slash and longleaf on old-field sites (table 9).

The scrub oak sites in the Sandhills are among the most difficult planting chances, and a great deal of research effort was spent in developing effective and economical methods of site preparation. One method recommended is to clear, plow, and drag the area

completely and then allow 6 months for soil stabilization before planting. An alternative is to plow furrows 6 to 8 feet apart, and if it is a 2-step operation, allow a minimum of 30 days for soil stabilization. In a 1-step operation the trees are planted without delay (fig. 46).

Cottonwood Plantations

The fast growth of cottonwood has stimulated interest in its use in the conversion of low-quality stands in the stream bottoms of the Georgia Piedmont (fig. 47). One small plantation, planted in 1956 on the Oconee

Table 9.—Prescription planting on old-field sites

Longleaf Pine — Sandhills Sites

	Grade 1* Expected Survival Unfurrowed	Grade 1* Expected Survival Furrowed**	Grade 2* Expected Survival Unfurrowed	Grade 2* Expected Survival Furrowed**
All sandy soils; deep sands, loamy sands, sandy loams..........	40-45%	70-75%	30%	50%
Spacing (feet)....................	6 x 5	6 x 8	6 x 4	6 x 6

*Grade 1, 1/4″ plus at root collar; Grade 2, 3/16-1/4″ at root collar. Root length at least 5″ and well developed lateral roots.
**Seat bottom of bud on top of loose soil raised by planting shoe to avoid silting over bud.

Spacing and number per acre:

6 x 4........	1815	6 x 7........	1037
6 x 5........	1452	6 x 8........	907
6 x 6........	1210	6 x 9........	807

Slash Pine — Sandhills Sites

	Grade 1* Expected Survival Unfurrowed	Grade 1 Expected Survival Furrowed	Grade 2* Expected Survival Unfurrowed	Grade 2 Expected Survival Furrowed	Grade 3* Expected Survival Unfurrowed	Grade 3 Expected Survival Furrowed	Grade 3 Expected Survival Furrowed & Planted Deep**
Deep Sands..................	60%	80%	50%	70%	30%	50%	65%
Normal Spacing (Feet).........	6 x 7	6 x 9	6 x 6	6 x 8	6 x 4	6 x 6	6 x 8
Loamy Sands.................	65%	85%	55%	75%	30%	60%	75%
Normal Spacing (Feet).........	6 x 8	6 x 9½	6 x 6	6 x 9	6 x 4	6 x 7	6 x 8½
Sandy Loam	70%	90%	60%	80%	45%	65%	80%
Normal Spacing (Feet).........	6 x 8	6 x 10	6 x 7	6 x 9	6 x 5	6 x 8	6 x 9

*Grade 1 specification: Top 6-14″, stem diameter 3/16″ at ground level (root collar).
*Grade 2 specification: Top 6-12″, stem diameter 1/8-3/16″ ground level (root collar), all secondary needles.
*Grade 3 specification: Top 3-8″, stem diameter 1/16-1/8″ ground level (root collar), at least 5 bundles of secondary (long) needles.

Root length at least 5″ for all grades, and well developed lateral root system.

Keep roots moist at all times with soupy mud or wet moss and covered with wet burlap. Do not let stand in water.

**If grade 3 (small) seedlings are planted deep in furrows—so just the bud is above ground line—survival is increased by at least 15-30%. Planting bar or machine must go deep enough to avoid U-rooting.

Spacing and number per acre:

6 x 4........	1815	6 x 7........	1037
6 x 5........	1452	6 x 8........	907
6 x 6........	1210	6 x 9........	807

River bottom near Athens, Georgia, has been quite successful. In the fall of 1956 the survival was 88 percent and the mean height was 7 feet (fig. 48). Now, at the end of the third growing season, survival is 66 percent and the mean height is 19 feet (fig. 49).

A severe freeze in February 1958 split the bark at ground line on some trees and they began to die during the growing season (fig. 50). Two fungi, *Dothichiza populea* and *Cytospora chrysosperma*, were found in the damaged areas, but the infections and mortality losses were confined to the freeze-damaged trees.

Photo by West Virginia Pulp and Paper Co.

Figure 46.—One-step method of partial scrub oak eradication and planting. Slash pine planted in deep furrows by HD-9 tractor and a modified Mathis plow in tandem with a tree planting machine.

Figure 47.—A cottonwood in the Oconee River bottom near Watson Springs, Georgia. At 43 years this tree is 32 inches in diameter and has $3\frac{1}{2}$ logs to a fork.

Figure 48.—Cottonwood plantation during midseason of the first year.

Figure 49.—Several trees in the 1956 cottonwood planting exceeded 30 feet in height by the end of the third year.

Figure 50.—Freeze-damaged tree dying during June of the third year.

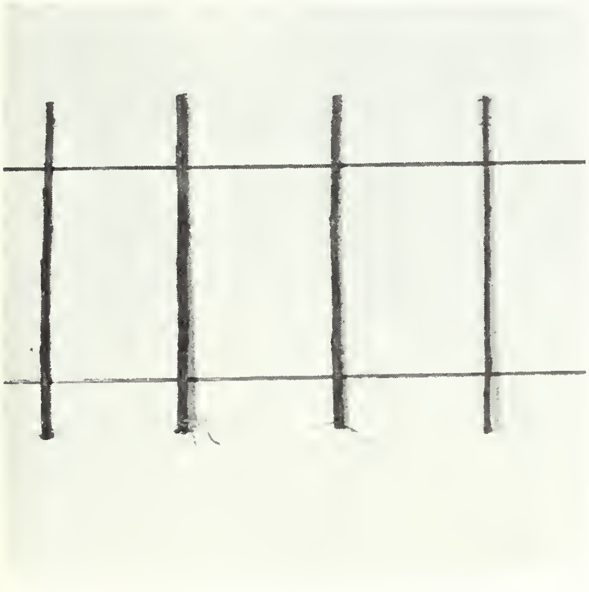


Figure 51.—The first roots originate in the basal callus. Buds are beginning to swell.

Rooting Cottonwood Cuttings

Cottonwood is an easily rooted species; yet little has been known of the time rooting begins or the relation of top growth to root growth. Several studies with green ash, yellow-poplar, and sweetgum had shown that the development of the crown was not indicative of root growth. A small study at the Athens-Macon Research Center now suggests that cottonwood rooting begins in early April and that the first sign of leaf development does indicate that rooting is under way (fig. 51). The larger cuttings produce more roots than do the smaller cuttings, and crown development generally follows the same pattern (fig. 52).

Figure 52.—Both roots and crowns are well developed on most cuttings. The cuttings with poor roots also have poor crowns.

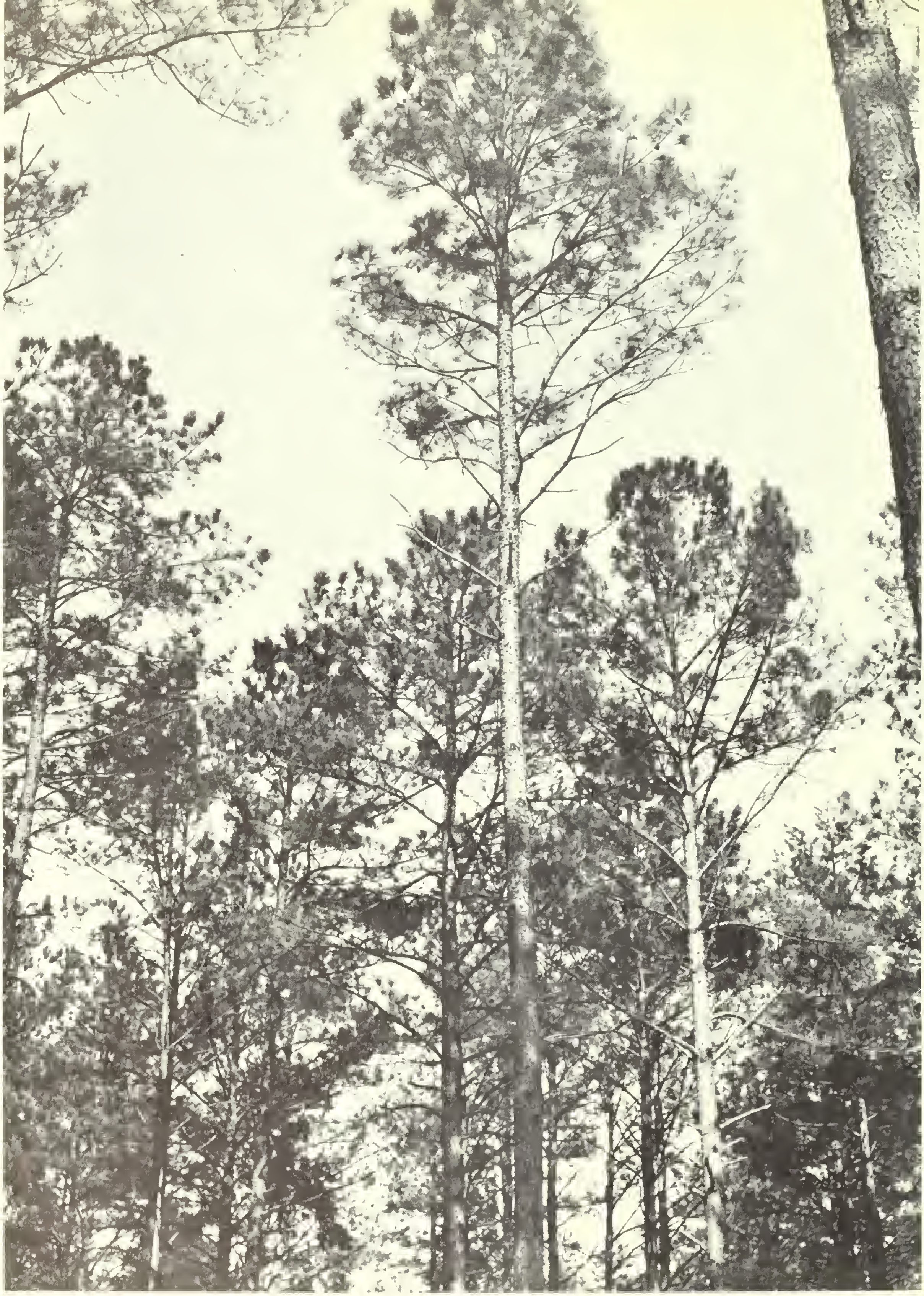


Figure 53.—A released tree, showing the size of opening that relieved the tree from competition and brought about a substantial increase in cone crops.

NATURAL REGENERATION

Most foresters realize that planned natural seeding as well as planting is needed to reverse the present trend setting so strongly toward conversion of pine to low-grade hardwoods. Hardwood stands on pine sites can be converted to pine only by planting, but a high proportion of the pine area harvested each year must be reproduced naturally. This successful natural regeneration will require proper treatment to insure adequate pine seed production, to prepare the seedbed, and to control competing vegetation.

Loblolly Pine in the Coastal Plain

The proper treatments needed for successful natural regeneration of loblolly pine in the coastal plain have been tested and the recommendations are available. The U. S. Department of Agriculture Production Research Report No. 13, "Natural Regeneration of Loblolly Pine in the South Atlantic Coastal Plain," by Karl F. Wenger and Kenneth B. Trousdell, was published in January 1958. This report is an excellent example of the results of carefully planned and well-sustained research.

Ten years ago natural regeneration of loblolly pine was the number-one forest management research problem in the coastal plain. A planned attack on the problem began in 1946 with the summarizing and testing of earlier findings and the designing of new studies to bridge the gaps. Some basic studies investigated the periodicity of seed production; others related seed production to tree characteristics such as age, size, and past fruitfulness. Relating seed production to environment and treatment resulted in specific recommendations for the timing and degree of effective seed tree release (fig. 53). Matching the requirements for germination and initial establishment with the effects of logging and site preparation produced the prescriptions for coordinating the seed supply with the seedbed (table 10).

While the techniques recommended in this report cannot be considered as absolute and final, they are well proven and have changed the picture so that natural regeneration is no longer classed as a major research problem in the coastal plain. With this accomplishment behind them our Franklin and Charleston Research Centers have shifted their programs more to the problems of managing young loblolly pine stands.

Table 10.—Approximate minimum number of loblolly pine seed trees per acre needed to attain the specified stocking of reproduction in the first year after tractor logging [1/]

Desired reproduction (percent of mil-acres stocked)	Seed trees per acre when diameter at breast height in inches is-- 8	10	12	14	16	18	20
	- - - - - - - Number - - - - - -						
GOOD SEED YEAR							
40	43	17	9	5	4	3	3
60		37	19	11	7	5	3
75		67	35	20	13	9	6
90			70	41	25	17	12
MEDIOCRE SEED YEAR							
40		38	18	10	6	4	3
60		82	38	21	13	9	6
75			69	39	24	16	11
90				79	49	33	23
POOR SEED YEAR							
40			67	32	19	12	8
60				69	40	25	18
75					73	47	32
90							65

1/ The numbers of trees shown are those required to attain the specified stocking of reproduction on the logged area as a whole, rather than on a single seedbed condition. To determine the number of seed trees needed on areas where burning or disking has been done in addition to logging, multiply the tabular figures by the following factors: logged and burned--2/3, disked and logged--1/3.

Not less than three trees per acre should be left under any conditions, since wider spacing might prevent adequate pollination and reduce seed production.

Loblolly Pine in the Piedmont

The methods of natural regeneration that have been so effective in the coastal plain may need some adaptation in the Piedmont because of lower seed production there. Seed-trap records from 1952 to 1956 on the Hitchiti Experimental Forest near Macon, Georgia, show adequate seed production in only 2 of the 5 years (table 11). Similar records taken on the Santee Experimental Forest near Charleston, South Carolina, show consistently high annual yields of seed.

Many loblolly pine stands in the South Carolina coastal plain probably could be regenerated without residual seed trees if

Table 11.—Loblolly pine seed production in the Georgia Piedmont and the South Carolina Coastal Plain

Seed year	Georgia Piedmont: Uncut stand 55 years old 1/	Georgia Piedmont: Seed-tree stand 60 years old 1/	Georgia Piedmont: Shelterwood stand 65 years old 1/	South Carolina Coastal Plain: Uncut stand 50 years old 1/	South Carolina Coastal Plain: Improvement-cut stand 50 years old 1/
	Thousands of sound seed per acre				
1952	139	73	304	101	164
1953	(2/)	9	7	240	320
1954	2	6	13	361	405
1955	214	184	445	696	542
1956	2	1	9	113	98

1/ Stand age in 1952.
2/ Less than 500 seeds per acre.

harvested after seedfall. The lower and more erratic seed production in the Piedmont may make it advisable to maintain a good residual seed source until the area is adequately stocked with seedlings.

STAND IMPROVEMENT

The phenomenal expansion of tree planting in the Southeast tends to overshadow the equally important increase in timber stand improvement work. Thousands of acres of timber are growing faster and are producing higher quality timber following treatment. Often the costs of these treatments must be regarded as long-term investments.

Prescribed Burning Can Pay Its Way

An exception to this rule turned up on the Santee Experimental Forest. Periodic winter burns were prescribed for a loblolly pine stand to maintain control of a hardwood understory in order to simplify natural regeneration of the pine in the late 1960's. An unexpected benefit was realized in 1957, when improvement cuts were made in the burned stand and the adjacent unburned check stand. The reduction in the number of hardwood stems 2 inches and larger in diameter after burning made logging easier and cheaper (table 12). Cash values of the reduced logging costs were $2.29 per thousand board-feet and $1.50 per cord when local rates for equipment and labor were used. These values can be considered as potential stumpage returns and are in addition to other such tangible benefits as reduced marking and protection costs (fig. 54).

Bud Pruning Slash Pine

Bud pruning has been tested on most of the important pine species and has usually given poor results. Slash pine is no exception; bud pruning seriously reduces both diameter and height growth (table 13).

These results are from a slash pine bud pruning study on the George Walton Experimental Forest near Cordele, Georgia. The trees were planted in 1948 and first pruned in 1950. The selected trees were pruned 3 to 4 times each year until pruning heights reached 17 feet. The bottom whorls that were left on half of the pruned trees were alive and vigorous in 1955. By 1958 most of the branches were dead, although on some trees they have developed into extremely large branches (fig. 55). Many of the pruned trees have crooked boles or forks. The combination of poor growth and poor form is more than enough to make bud pruning unprofitable and not recommended in slash pine.

Figure 54.—Two adjacent units after the second improvement cut in a 50-year-old loblolly pine stand: Left, Area 1, one year after third prescribed winter burn, is easy to work in. Right, Area 2 has had no prescribed burning and the heavy understory slows down logging and related forestry activity.

Table 12.—Equipment and man-hours to log burned and unburned stands of loblolly pine

Area	Sawtimber		Pulpwood	
	Equipment	Labor	Equipment	Labor
	- - - Hours per M board feet 1/ - - -		- - - Hours per cord - - -	
Unburned stand	0.81	3.1	0.77	5.7
Burned stand	.59	2.3	.59	4.7
Percent reduction	27	26	23	18

1/ Scribner Decimal C. log rule.

Table 13.—Diameter and height of bud pruned and unpruned slash pine

Plantation spacing (feet)	Unpruned		Pruned except for bottom whorl		All laterals pruned	
	D.b.h.	Height	D.b.h.	Height	D.b.h.	Height
	Inches	Feet	Inches	Feet	Inches	Feet
DECEMBER 1955						
6x6	4.1	23	3.5	22	2.9	22
12x12	5.5	24	4.0	21	3.0	21
DECEMBER 1958						
6x6	5.2	35	4.1	30	3.3	30
12x12	7.0	37	5.2	32	3.7	28

Figure 55.—The bottom whorl of branches on this 10-year-old slash pine, bud pruned in 1950, was still alive and vigorous in 1958. Bud pruning slash pine has proved worthless.

Timber Stand Improvement in the Appalachians

Timber stand improvement in the Appalachians is complicated by the varied mixture of species, tree sizes, and timber quality to be found in any one stand. Because timber quality rather than species or size is the chief criterion for desirability, we must use the more expensive single-tree treatments. Since the response to treatment varies by species and tree size, the treatments must be tailored accordingly.

Recommendations for the control of competing trees and shrubs (table 14) are the results of a study testing 11 treatments on six species and species groups on the Bent Creek Experimental Forest. No one treatment is effective on all species over all size groups. Of the species tested, red maple and rhododendron are the most difficult to control.

Table 14.—Treatments recommended for each species and size group

Species	Size	Treatment
Oak	Sapling	Ammate crystals on stumps, 1 tablespoon per 2 inches of diameter.
Oak	Poletimber	Ammate crystals in cups, 1 tablespoon per cup; 1 cup per 2 inches of diameter. Or 2, 4, 5-T in oil in ax-frills, 8 lbs. acid equivalent per hundred gallons.
Oak	Sawtimber	Any good girdling treatment; silvicide not necessary.
Hickory	Sapling	2, 4, 5-T in oil on stumps, 20 lbs. acid equivalent per hundred gallons. Or Ammate crystals, 1 tablespoon per 2 inches of diameter.
Hickory	Poletimber	2, 4, 5-T in ax-frills, 8 lbs. acid equivalent per hundred gallons.
Hickory	Sawtimber	Ax-girdles (frill or notch); silvicide not necessary.
Red maple	Sapling	Basal spray, 2, 4, 5-T basal spray, 20 lbs. acid equivalent per hundred gallons.
Red maple	Poletimber	No treatment tested was satisfactory.
Sourwood	Sapling	Ammate crystals on stumps, 1 tablespoon per 2 inches of diameter.
Sourwood	Poletimber	Ammate crystals in cups, 1 tablespoon per cup; 1 cup per 2 inches of diameter.
Rhododendron	--	2, 4, 5-T in oil on stumps, 20 lbs. acid equivalent per hundred gallons.
Laurel	--	2, 4, 5-T in oil on stumps, 20 lbs. acid equivalent per hundred gallons. Or basal spray.

SILVICS

The 1958 additions of personnel and program shifts were heavily weighted toward silvical research. Many of the study results, such as new site indices and yield tables, can be used immediately by field foresters. The results of the more fundamental studies may have no practical application now, but they do supply a solid foundation for applied research in the future. The research of Dr. Barnes is a good example; one of the end results of his work will be increased seed production, yet his current studies are limited to the investigation of metabolic compounds and processes involved in the physiology of flowering. Complete understanding of the physiology of flowering will take a long time; yet this knowledge must be available before we can exert any real control over seed production. The less basic but equally important soils-site studies will yield usable information in a much shorter time.

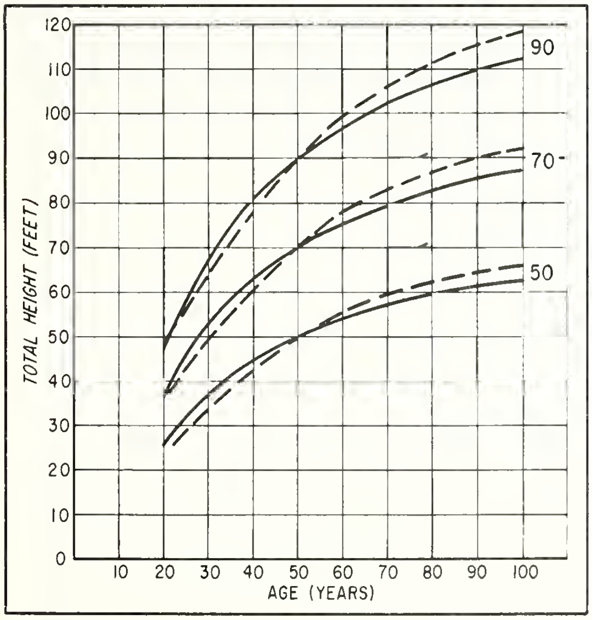


Figure 56.—New site index curves (solid line) for white, northern red, southern red, scarlet, black, and chestnut oak in the Virginia-Carolina Piedmont and the southern Appalachian Mountains compared with those in Technical Bulletin 560 (broken line).

Site Indices for Oak

The height-age curves for oak in U. S. Department of Agriculture Technical Bulletin 560 have been used throughout the eastern United States for over 20 years. The curves were based upon 404 plots scattered from Georgia to Michigan and from Missouri to Michigan, and have been quite satisfactory. The recent soil-site studies in the Virginia-Carolina Piedmont and in the Southern Appalachian Mountains have supplied a total of 697 oak plots that give more precise data for this area. New curves for white, northern red, southern red, scarlet, black, and chestnut oak were prepared, using these data. Data were analyzed separately by species and then combined, as the slope coefficients showed no significant differences. These new curves (fig. 56) are quite close to those in Technical Bulletin 560. Site index estimated from the new curves is a few feet lower for ages under 50 years, and a few feet higher for ages over 50 years. Since the differences are small and the new indices are limited to only a portion of the area sampled for the old indices, any speculation as to the significance of these differences would not be worth while. The new indices should be used for the Virginia-Carolina Piedmont and for the Southern Appalachian Mountains. The Technical Bulletin 560 indices should be used for the other areas.

Soils-Site Studies

Soils-site studies are a major activity at many of the research centers. Soil-site indices and yield tables for both volume and weight of plantation-grown slash pine will be published in 1959. The soils-site relationships for some of the important hardwood species in the Carolina Piedmont are being analyzed and the results will soon be available. The Athens-Macon Research Center has expanded its soil-site work to include the mountains of north Georgia (fig. 57) as well as the Georgia Piedmont. The Asheville Research Center and the Charlottesville, Virginia, unit will also have substantial studies under way in the Piedmont and mountains during 1959. These studies will be supplemented by the regional investigations of the effects of stand density, age, and site on growth and yields.

Figure 57.—Soil sample collected in north Georgia by the Athens-Macon soils-site crew will be sent to the soils laboratory at Union for analysis.

Stand Density Studies

Preliminary 5-year results of the regional study of the growing space requirements of loblolly pine were published in our Station Paper 97. These partial results indicate that a low level of stand density is best for a poor site but a good site will support a relatively high stand density throughout the rotation. The failure to show optimum densities may have been due to the limited range of densities sampled. Additional plots were thinned at the beginning of the second 5-year period and the chances of determining optimum levels should be much better at the end of the current period.

A similar study in natural slash pine stands will soon be ready for its first remeasurement. Both studies will be supplemented by new studies in slash and loblolly pine plantations. The slash pine plantation study will be a joint project of the Cordele and Lake City Research Centers. The loblolly pine plantation study will be handled by the Athens-Macon Research Center. Both studies will be greatly strengthened by industry's participation in the installation and maintenance of plots on company lands.

The Asheville Research Center is preparing a work plan for a stand density study for mixed hardwoods in the Piedmont and mountains. This study will be more complex than the pine studies because of the effect of site on species composition and the interaction of site and species composition on growth and timber quality.

Influence of Topography on Species Composition

Observations made on the Hitchiti Experimental Forest near Macon, Georgia, show that the rate of hardwood invasion in the Georgia Piedmont is strongly influenced by aspect, degree of slope, and position on the slope (fig. 58). A dense loblolly pine overstory retarded the growth of the hardwood understory but had little effect on the occurrence of the hardwoods.

Three general conclusions can be drawn from the correlation of the influence of topography on the rate at which hardwoods invade loblolly pine in the lower Piedmont.

1. Loblolly pine can usually be perpetuated without hardwood control on all gentle upper slopes and on moderate upper slopes with a southerwestern exposure.
2. Loblolly pine can be perpetuated if hardwood control measures are practiced on steep upper slopes with a southwestern exposure, moderate upper slopes with a northeastern exposure, and on all moderate lower slopes.
3. Loblolly pine will be difficult and perhaps unprofitable to perpetuate because of hardwood competition on steep upper slopes with a northeastern exposure, all steep lower slopes, and in bottoms.

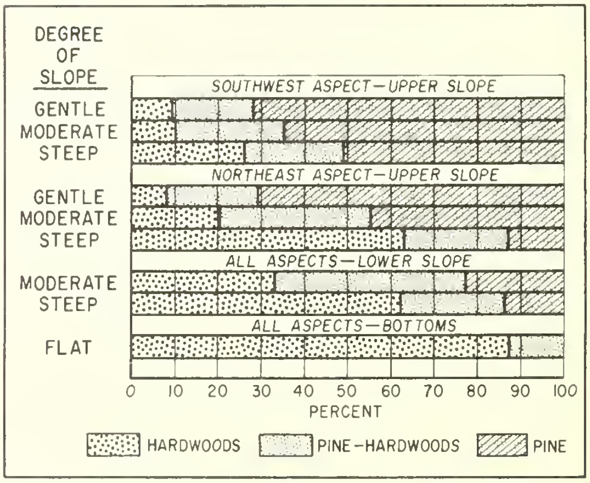


Figure 58.—Distribution of loblolly pine understory types in relation to aspect, degree of slope, and position on slope at the Hitchiti Experimental Forest in Georgia.

FARM WOODLAND MANAGEMENT

Forestry progress is lagging badly on small ownerships in the South; the real gains have been made by wood-using industries, large landowners, and public agencies. Most farm woodlands and other small holdings produce only a small fraction of the wood and income they could yield under reasonable management. Reliable costs and returns information and on-the-ground demonstrations of good forest management are needed to encourage small owners to intensify their woodland management. The farm woodland demonstration-test on the George Walton Experimental Forest, near Cordele, Georgia, meets these needs for its immediate area.

Costs and Returns

Annual cash returns as high as $9.00 per acre may be obtained from managed woodlots in the Georgia Coastal Plain (table 15). When management began in 1950, many of the second-growth and almost all of the old-growth trees were of poor form and were not desirable growing stock. Most of the volume was slash pine, with some longleaf and loblolly pine. An improvement cut in 1950 removed most of the poor trees. The returns were not included in table 15, because this cut is considered as preparatory to management.

Naval stores operations on the woodlot are carried on as an integral part of management. Trees to be harvested are marked 4 to 5 years in advance of the cut, worked for 4 years, and then harvested in the regular cyclic cut. The first naval stores operation, installed in 1952, utilized improved techniques of bark chipping, acid stimulation, and removable tins on 553 faces.

The second cyclic cut was made in 1956 and included 1,495 board-feet of sawtimber, and 2.49 cords of pulpwood per acre. In 1957, 532 faces on trees designated to be removed in the third cutting cycle were cupped.

Table 15 is a complete listing of costs and returns on the woodlot, including costs of cultural operations, such as control of undesirable hardwoods and the periodic pruning of future crop trees when called for. Net income for the first 7 years the stand was under management was $63.37 per acre, or $9.05 per acre per year. Sawtimber volume has grown during this period at an annual rate of 342 board-feet per acre. Increases in the per-acre growth are expected as stocking is built up. Pulpwood volumes have been reduced, but a rapid increase is expected in the near future as seedlings and saplings reach pulpwood size. While we were achieving this income, proper management has produced healthy, fast-growing stands so that even larger returns may be expected in the future.

FOREST GENETICS AND TREE IMPROVEMENT

If a good job of forest management is to be done now, the genetic quality of the trees must be considered when seed is collected, when seedlings are purchased, when improvement cuts are made, or when the final crop is harvested. Such consideration will be effective if based on the findings of a well-rounded forest genetics research program. Our present program at Macon, Georgia, is directed toward selection and breeding of pine for improved growth, form, disease resistance, and wood quality (fig. 59). Studies of racial and within-stand variation are under way and progeny-testing techniques are being improved. At Lake City, Florida, the project in developing high gum-yielding strains of slash pine is being continued, and seed orchards to produce seed of improved strains have been established. The original program has been broadened to include selection and breeding slash pine for traits other than gum yields. The other research centers also participate in racial studies of yellow-poplar, red oak, hemlock, and the southern pines.

Certified Seed

Prompt acceptance of the findings of tree improvement research has resulted in the establishment of certification standards for forest tree seed in Georgia. By 1960 it will be possible for a seed producer to market seed bearing the blue tag "CERTIFIED SEED" of the Georgia Crop Improvement Association. Under the Georgia Standards, seed will be certified as Class I, II, or III. Class I will be reserved for seed produced from progeny-tested clones in seed orchards or from controlled pollinations of progeny-tested elite trees. Class II includes seed from seed orchards prior to completion of progeny tests

and open-pollinated seed from progeny-tested elite trees. Class III seed are from seed production areas or from open-pollinated plus trees. An isolation strip is required for all production except where controlled pollination is used.

Eventually, Class III seed will be dropped from the list, but it is presently the largest potential source of certified seed. A number of years will elapse before quantity production of Class I seed can begin, because of the time involved in progeny testing. These progeny tests must be maintained until the Georgia Crop Improvement Association has accepted the data presented on them and is satisfied as to the genetic quality of the seed.

Table 15.—Farm woodland costs and returns, 1950 to 1956, George Walton Experimental Forest

Date	Management action	Income per acre	Cost per acre
		Dollars	Dollars
1952	Hardwood control, 0.49 man-hour per acre at $0.80 per man-hour	--	0.39
1952	Pruning, 0.28 man-hour per acre at $0.80 per man-hour	--	.22
1952	Cost of naval stores materials	--	2.49
1952	Naval stores operation, 0.485 bbl. per acre at $23.58 per bbl.; 7.89 man-hours per acre at $0.80 per man-hour	11.44	6.31
1953	Naval stores operation, 0.472 bbl. per acre at $23.58 per bbl.; 6.74 man-hours per acre at $0.80 per man-hour	11.13	5.39
1954	Naval stores operation, 0.465 bbl. per acre at $24.40 per bbl.; 6.61 man-hours per acre at $0.80 per man-hour	11.35	5.29
1955	Naval stores operation, 0.400 bbl. per acre at $26.10 per bbl.; 6.76 man-hours per acre at $0.80 per man-hour	10.44	5.41
1956	Timber marking and scaling, 0.80 man-hour per acre at $1.85 per man-hour	--	1.48
1956	Sawtimber harvest, 1.495 M board feet per acre at $27.60 per M	41.26	--
1956	Pulpwood harvest, 2.49 cords per acre at $4.60 per cord	11.45	--
1950-1956	Taxes at $0.17 per acre per year x 7 years	--	1.19
1950-1956	Protection at $0.79 per acre per year x 7 years	--	5.53
	Totals	97.07	33.70
	Net return	63.37	
	Annual net return	9.05	

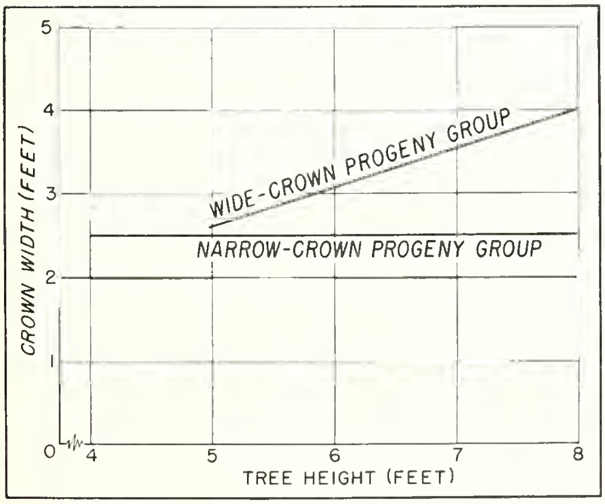


Figure 59.—Tests in Georgia show that crown width and branch length are strongly inherited. Upper left, typical wide-crown seedling (4 years old) from wide-crown mother tree. Upper right, typical narrow-crown seedling (4 years old) from narrow-crown mother tree. Graph illustrates tendency of the wide-crown trees to get wider as they grow taller, whereas the narrow-crown progeny stay narrow. By selection, which is the simplest, quickest method of tree improvement, we have also isolated strains of trees that inherently produce high or low gum yield, heavy or light wood, and long or short fibers.

Slash Pine Seed Source Trial

Early results of local seed source trials lead to the belief that stands at the extreme north and extreme south portion of the range of slash pine are inherently slower growing than those in the central portion.

Fourteen lots of seed collected in various portions of the range of slash pine were sown at Lake City in the spring of 1954. Three of the lots were from separate localities near the north extremities of the range of slash pine, two in central Florida, and the remaining nine lots were from the interior portion of the species range in south Georgia and north Florida. Seedlings grown from them were outplanted in five localities in the winter of 1954-55. Average total heights (as of the winter of 1957-58) of progenies from within the three broad "zones" outlined are summarized in table 16.

Progenies from the central portion of the range of slash pine averaged tallest at all planting sites. Although the superiority of these sources was small when planted in Georgia and south Florida, it was more substantial in north Florida. Progenies generally grew fastest to date at the Effingham County, Georgia, site and poorest at the Lake County, Florida, site, while differences among the remaining three sites were small.

Seed-source effects upon survival were rather small, except that survival percents for the two central Florida lots were lowest at all plantations. Planting-site effects on survival were rather large, on the other hand, with survival the greatest at the two north Florida sites.

Definite conclusions cannot, of course, be drawn from these tests until the progenies are older. Final results will be important because of the rather common practice at present of collecting seed from south-central Georgia for planting in north Florida. The early results indicate that it may be wise to avoid collecting seed from the extreme northerly portion of the species range for planting in south Georgia and north Florida.

Table 16.—Mean total heights and survival of slash pine progenies from different sources planted the winter of 1954-55 in five localities. Data taken the winter of 1957-58

Seed source locality	Planting sites				
	South Georgia		North Florida		South Florida
	Dooley County	Effingham County	Liberty County	Baker County	Lake County
	Mean total height--feet				
South central Georgia 1/	3.2	4.8	2.8	2.8	2.1
Extreme south and southeast Georgia and north Florida 2/	3.5	4.9	3.3	3.2	2.2
Central Florida 3/	3.4	4.5	2.9	2.6	2.1
	Survival--percent				
South central Georgia 1/	51.7	52.9	72.8	81.9	51.8
Extreme south and southeast Georgia and north Florida 2/	49.5	44.8	73.5	81.0	49.8
Central Florida 3/	33.2	40.2	65.6	62.3	45.2

1/ Seed sources were from each of the following Georgia counties: Calhoun, Laurens, and Dooley.

2/ Seed sources were from each of the following counties: Baker, Taylor, Calhoun, and Nassau, Florida; and Emanuel, Effingham, Brooks-Loundes, Jeff Davis, and McIntosh, Georgia.

3/ Seed sources were from each of the following Florida counties: Citrus and Volusia.

Air-Layering Slash Pine

A growth-regulator screening study conducted on air-layering of slash pine during the 1958 growing season indicates that naphthaleneacetamide may be a suitable, but not preferable, substitute for indolebutyric acid (table 17). Gibberellic acid gave very poor results and trichlorophenoxyacetic acid was a complete failure. Three of the chemicals were tested at concentrations of 1 percent and 2 percent, and the fourth, gibberellic acid, at 0.1 percent and 0.2 percent.

Air-layering was done on ten trees each from 20-year, 30-year, and 40-year age classes. Two air-layers were made in each tree for each chemical-concentration combination. The air-layers were made between July 24 and August 6 and were removed 10 weeks after installation.

Propagation Techniques Applicable to Longleaf Pine

Although appreciable literature exists concerning the vegetative propagation of loblolly, shortleaf, and slash pines, there is little published information regarding the vegetative propagation of longleaf. Longleaf pine has been propagated at Lake City, Florida, by cuttings, air-layering, and by bottle-grafting. While the percentages of successful takes with these three methods have been low on initial trials, it is important to know that longleaf pine can be propagated by the same techniques used with other southern pine species. With further tests, propagation techniques can probably be refined to give a greater degree of success.

A Truck-Mounted Ladder for Collecting Cones

The job of tree climbing will become increasingly important as tree-breeding programs are enlarged and as seed-production areas and orchards begin producing sizeable seed crops. In some instances trees from selected areas have been felled to facilitate cone collection, but in seed orchards established from clonal stock of superior parentage the trees will be too valuable to cut. To gather cones from these standing trees, the collector must either climb the tree and punch the cones off while working within the crown or gather cones by some other means from a vantage point outside of the crown.

As an aid to collectors, a ladder mount for a fire-fighting extension ladder has been designed (fig. 60). It is completely operable by one man. The mount, used on a ½-ton pickup truck, supports a 40- to 50-foot heavy-duty aluminum ladder. For taller trees the ladder rig can be used to gain access to the lower crown preparatory to climbing higher within the tree crown.

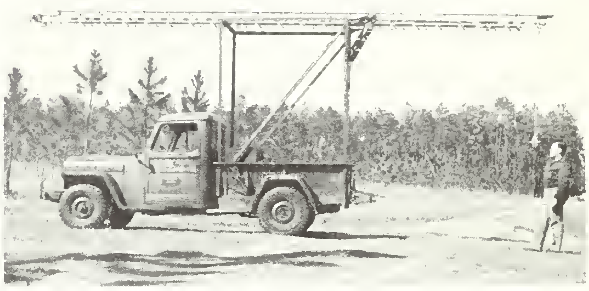


Figure 60.—Truck-mounted ladder in travelling position.

Table 17.—Comparison of slash pine air-layer-rooting response to three plant growth regulators in three tree age-classes

Tree age-class (years)	Indolebutyric acid concentration		Naphthaleneacetamide concentration		Gibberellic acid concentration	
	1 percent	2 percent	1 percent	2 percent	0.1 percent	0.2 percent
	Percent of air-layers rooted					
20	30	10	30	10	5	5
30	10	10	15	10	0	0
40	10	15	10	0	0	0

NAVAL STORES

Naval stores research at Lake City, Florida, includes both fundamental and applied studies. Past investigations of the role of chemical treatment in stimulating resin flow have led to the development and general acceptance of bark chipping with acid stimulation. These investigations have shown that the acid does not stimulate resin production but merely facilitates the outflow. Any real gains in resin production within the tree will depend upon the development of superior strains of high gum-yielding trees and by increasing gum yields through silvicultural practices. High-yielding strains are being developed by selection and breeding, and demonstration "gum orchards" are being established. Field tests of the effects of fertilization, cover crops, and irrigation on the growth and gum yields of both average- and high-yielding trees have been installed on the Olustee Experimental Forest.

While the methods and schedules of chipping have no effect upon the ability of a tree to produce gum, they do have a very real effect on the costs of gum extraction. A good deal of preliminary work on intensive chipping methods has been done, and pilot plant tests were carried on to determine the practicality of these techniques for commercial operations. This information and other information as to the effects of tree size and crown length on gum yields have been put to use in the Naval Stores Conservation Program.

Equipment development for efficient gum extraction has been another important phase of applied research. These improved tools have made it easier to gain public acceptance of the more conservative new extraction methods. While further improvements in hand tool design are possible, the next major "break through" will probably be the mechanization of the extraction process.

PUBLICATIONS
by
MEMBERS OF THE STAFF, INCLUDING COOPERATORS
Calendar Year 1958

Anderson, W. C.
A "MODIFIED DOYLE" RULE-OF-THUMB FOR ESTIMATING BOARD-FEET IN SMALL LOGS. Southeast. Forest Expt. Sta. Res. Note 116.
(Simple rule-of-thumb more accurate than Doyle rule in estimating board-foot volume of logs less than 18 inches in diameter.)

Black, P. E., and Clark, P. M.
TIMBER, WATER, AND STAMP CREEK. Southeast. Forest Expt. Sta., illus.
(Careful road layout and logging to minimize damage was well demonstrated on the Stamp Creek sale, Chattahoochee National Forest, Georgia.)

Bois, P. J., and Haigh, A. H., Jr.
THE RISING IMPORTANCE OF AGGREGATED WOOD PRODUCTS. Soc. Amer. Foresters Proc. 1957: 120-122.
(Discusses methods of fabrication and economics of producing various aggregated wood products from material hitherto considered waste.)

Boyce, J. S., Jr.
NEEDLE CAST OF SOUTHERN PINES. U. S. Dept. Agr. Forest Pest Leaflet 28, 4 pp., illus.
(A popular leaflet that describes the symptoms, causes, and control for pine needle blights, with emphasis on brown spot and *Hypoderma lethale*.)

Boyce, J. S., Jr.
TWIG BLIGHT OF EASTERN WHITE PINE CAUSED BY MONOCHAETIA PINICOLA. Phytopathology 48(9): 516-517.
(A small canker that results in twig blighting has been seen in several localities, and was proven to be caused by a little-known fungus.)

Boyce, J. S., Jr., and Stegall, W. A., Jr.
OBSERVATIONS ON OAK WILT DETECTION IN TENNESSEE IN 1957. Plant Dis. Rptr. 42(5): 707-709.
(Annual aerial surveys together with roadside observations and revisits to old wilt centers over a 5-year period located about 25 percent of the centers active during this period, as judged during a 100-percent ground survey in Green County, Tennessee.)

Brender, E. V.
A 10-YEAR RECORD OF PINE SEED PRODUCTION ON THE HITCHITI EXPERIMENTAL FOREST. Jour. Forestry 56: 408-410.
(Loblolly pine seed production lower in Piedmont than in Coastal Plain. Shelterwood stands produced more seed than seed tree stands, adequately stocked mature stands, or open-grown immature stands.)

Bryan, M. B.
FOREST STATISTICS FOR THE MOUNTAIN REGION OF VIRGINIA. Southeast. Forest Expt. Sta. Forest Survey Release 52, 52 pp., illus.
(Statistics on forest area, timber volume, growth, and cut, with trends in forest area and timber volume between the first and second surveys.)

Bryan, W. C.
DEFECT IN PIEDMONT HARDWOODS. Southeast. Forest Expt. Sta. Res. Note 115.
(Epicormic and adventitious branching led the causes of lowered quality of all species, followed by insect holes, sweep and crook, disease defects, birdpeck, and fire scars.)

Byram, G. M.
SOME BASIC THERMAL PROCESSES CONTROLLING THE EFFECTS OF FIRE ON LIVING VEGETATION. Southeast. Forest Expt. Sta. Res. Note 114.
(Quantity of heat required to raise temperature of living vegetation up to lethal temperature is directly proportional to difference between this temperature and initial vegetation temperature.)

Campbell, R. A.
DOES THE BUTT LOG DEFINE TREE GRADES? *In* Hardwood Sawlog-Grading Symposium Proc. 1957. Pub. jointly by Ill. Agr. Expt. Sta. and Purdue Agr. Expt. Sta., pp. 68-73.
(Brief discussion of history and theory of butt log tree grading. Examples of results given.)

Clements, R. W.
GUM NAVAL STORES. Forest Farmer Manual XVIII(7): 113-117.
(Describes and illustrates modern naval stores production methods and use of naval stores tools.)

Clements, R. W.
LONGER LIFE FOR NEW METAL CUPS ON ACID-TREATED TREES. Naval Stores Rev. 68(7): 6. Also in AT-FA Jour. 21(1): 14-15.
(Early installation of new metal cups permits accumulation of enough rainwater to minimize acid damage.)

Clements, R. W.
USING THE NEW HAMMER TOOL FOR RAISING TINS INSTALLED WITH DOUBLE-HEADED NAILS. Southeast. Forest Expt. Sta., 7 pp.
(Describes and illustrates techniques of using new hammer tool.)

Cooper, R. W.
FIGHTING FOREST FIRES FROM THE AIR. South. Lumberman 197(2465): 17-18.
(Reports tests of coverage and vegetation penetration of slurry from TBM aerial tanker.)

Cooper, R. W.
A GUIDE TO THE OLUSTEE EXPERIMENTAL FOREST. Southeast. Forest Expt. Sta., 26 pp., illus.
(An illustrated history and description of research program at Olustee Experimental Forest.)

Cooper, R. W.
SAND PINE REGENERATION IN FLORIDA. Soc. Amer. Foresters Proc. 1957: 71-72.
(Sand pine will regenerate naturally if stands are cut, tractor-logged, and skidded during May to December.)

Cooper, R. W., and Altobellis, A. T.
WARRING ON FIRE WITH CHEMICALS. Forest Farmer XVII(8): 4-5.
(Initial trials with sodium calcium borate show promise for the use of chemical fire retardants in the South.)

Cooper, R. W., and Olson, D. F., Jr.
VOLUME DETERMINATIONS FOR SECOND-GROWTH SLASH AND LONGLEAF PINE IN NORTHEAST FLORIDA. Southeast. Forest Expt. Sta. Paper 92, 11 pp.
(Presents cubic foot, board-foot—both Scribner and International 1/4-inch—and topwood tables for slash and longleaf pine.)

Doolittle, W. T.
SITE INDEX COMPARISONS FOR SEVERAL FOREST SPECIES IN THE SOUTHERN APPALACHIANS. Soil Sci. Soc. of Amer. Proc. 22(5): 455-458.
(Site indices of 10 species correlated; when site index of one species is known it is possible to estimate site indices for other species.)

Dorman, K. W., and Cossitt, Floyd
NEW CROP TREES—REFORESTATION BY NATURAL MEANS. Forest Farmer Manual XVIII(7): 71-72.
(Continuous use of forest land by harvesting methods that will assure regeneration through silvicultural management or by planting.)

Doyle, H. J., and Olson, D. F., Jr.
NORTH CAROLINA PIEDMONT HARDWOOD FOREST RESEARCH PROJECT. Southeast. Forest Expt. Sta., 24 pp.
(Plans and accomplishments of cooperative effort to speed up improvement of Piedmont hardwood forests.)

Froelich, R. C.
TIMBER CULL IN VIRGINIA AND THE CAROLINAS. Southeast. Forest Expt. Sta. Res. Note 121.
(Summary of timber cull studies giving relative importance and average board-foot and cubic-foot volume losses resulting from several types of cull by tree species group.)

Gruschow, G. F., and Trousdell, K. B.
INCIDENCE OF HEART ROT IN MATURE LOBLOLLY PINE IN COASTAL NORTH CAROLINA. Jour. Forestry 56: 220-221.
(Slow growth as well as old age contributes to susceptibility of loblolly pine to heart rot.)

Halls, L. K., and Ripley, T. H.
THE FUTURE OF WILDLIFE IN THE SOUTHERN FOREST. Forest Farmer XVIII(3): 5, 14-16.
(Survey of the status of forest-game habitat research in the South indicates significant accomplishments, but emphasizes need for much new research.)

Harper, V. L., Briegleb, P. A., and Pechanec, J. F.
WHERE WE ARE NOW IN FOREST RESEARCH—A REPORT ON 10 YEARS OF PROGRESS. Forest Farmer XVIII(2): 6-9, 28-29.
(Reviews major areas of forest research in South over last 10 years. Also indicates future needs and role research will play in supplying answers.)

Hepting, G. H.
FOREST DISEASES—A GROWING PROBLEM. The Unit 74: 26.
(Diseases have greater impact on southern timber growth than any other destructive agent. Discusses the present status of damage, control, and research for the South's main diseases.)

Hepting, G. H.
OUR CURRENT RESEARCH NEEDS: FOREST TREE DISEASES. Forest Farmer XVIII(2): 14.
(Cites special need for fundamental research on diseases, expanded work on main forest and nursery diseases, a greater effort in such new fields as nematodes, seed diseases, et al., and better disease surveys.)

Hepting, G. H.
SOUTHERN CONE RUST. U. S. Dept. Agr. Forest Pest Leaflet 27, 4 pp., illus.
(Account of the occurrence of cone rust, species affected, damage caused, life history, and control possibilities.)

Herrick, A. M.
GRADING AND MEASURING HICKORY TREES, LOGS, AND PRODUCTS. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 7, 18 pp., illus.
(A report on measuring and grading systems applied to hickory trees, logs, and more specialized products.)

Hewlett, J. D.
PINE AND HARDWOOD FOREST WATER YIELD. Jour. Soil and Water Conserv. 13(3): 106-109.
(Investigations are expected to show comparative water-use requirements of pine vs. hardwood stands. Early studies suggest white pine provides satisfactory watershed protection and regulation of water yields.)

Hodges, C. S.
THE EFFECT OF FUMIGATION ON THE RELATIVE ABUNDANCE OF SOIL MICROORGANISMS. (Abs.) Assoc. South. Agr. Workers Proc. 1958: 222-223.
(Soil population counts made at intervals after fumigation showed Vapam and methyl bromide selective in action against fungi, actinomycetes, and bacteria, while these organisms responded similarly to steam.)

Johansen, R. W., and Arline, L.
AN IDEA IN TRUCK-MOUNTED LADDERS. Jour. Forestry 56: 852-853, illus.
(Description of truck-mounted ladder for use in seed orchards, seed production areas, and in tree breeding programs.)

Johansen, R. W., and Kraus, J. F.
PROPAGATION TECHNIQUES APPLICABLE TO LONGLEAF PINE. Jour. Forestry 56: 664.
(Longleaf pine can be vegetatively propagated by cuttings, grafting, and air layers with same techniques used for other southern pines.)

Johnston, H. R., Smith, R. H., and St. George, R. A.
CONTROL OF LYCTUS POWDER-POST BEETLES IN LUMBER YARDS AND PROCESSING PLANTS. Pest Control Mag. 26(1): 39-42.
(Discussion of life history, habits, measures of preventing attacks, and control of powder-post beetles.)

Keetch, J. J.
RELATIVE FIRE DANGER DESCRIPTIONS FOR METER 8 AND METER 8-100. Southeast. Forest Expt. Sta. Res. Note 117.
(Indicates relative fire occurrence and describes probable fire behavior according to 5 classes of burning index.)

Keetch, J. J., and Gladstone, M. C.
1957 FOREST FIRES AND FIRE DANGER IN CONNECTICUT, KENTUCKY, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, VERMONT, VIRGINIA, AND WEST VIRGINIA.
(Thirteen separate state reports containing tables and graphs analyzing forest fires and fire danger.)

Kowal, R. J.
FOREST ENTOMOLOGY IN SOUTHERN UNITED STATES. Tenth Internatl. Cong. Ent. Proc. 1956: 399-406.
(Historical review of research in forest entomology in southern United States, review of current problems and research, and statement on what is foreseen in future.)

Kowal, R. J.
MEETING THE PROBLEM OF TREE-KILLING INSECTS. Forest Farmer Manual XVIII(7): 38-40.
(Report of progress in improving detection and reporting of insect outbreaks and in research on control of important southern forest pests.)

Kowal, R. J.
THE PRESENT STATUS OF FOREST INSECTS. The Unit 74: 24-25.
(Discussion of primary forest insect problems, particularly as they affect the pulp and paper industry, and progress and needs in forest insect surveys and research.)

Kowal, R. J., and Rossoll, Harry
BEETLES IN YOUR PINES? Southeast. Forest Expt. Sta., 29 pp., illus.
(Recognition, life history, prevention of damage, and control of Ips, black turpentine, and southern pine beetles.)

Kraus, J. F.
TWENTY NON-INDIGENOUS PINES GROW IN NORTH FLORIDA. Silvae Genetica 7, Heft 2.41-80, p. 69.
(Lists three Asiatic, five European, and twelve North American pines growing in the arboretum on the Olustee Experimental Forest.)

Langdon, O. G.
CONE AND SEED SIZE OF SOUTH FLORIDA SLASH PINE AND THEIR EFFECTS ON SEEDLING SIZE AND SURVIVAL. Jour. Forestry 56: 122-127.
(Large seed from small cones gave best survival. Large- and medium-size seedlings survived better than small seedlings.)

Langdon, O. G.
EARLY TRENDS IN A SLASH PINE SEED SOURCE STUDY IN SOUTH FLORIDA. Southeast. Forest Expt. Sta. Res. Note 123.
(Third-year results indicate slash pine from center of slash pine range grew better in south Florida than seedlings from either northern or southern fringes of range.)

Langdon, O. G.
SILVICAL CHARACTERISTICS OF BALDCYPRESS. Southeast. Forest Expt. Sta. Paper 94, 24 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Langdon, O. G.
VOLUME TABLES FOR SOUTH FLORIDA SLASH PINE (PINUS ELLIOTTII VAR. DENSA, LITTLE AND DORMAN). Southeast. Forest Expt. Sta. Res. Note 120.
(Cubic-foot and board-foot tables—both Scribner and International ¼-inch—for South Florida slash pine.)

Lehman, J. W.
PRODUCTS FROM HICKORY BOLTS. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 6, 20 pp., illus.
(Presents information on size, quality, and grade requirements of hickory bolts in use today. Specifications for bolt products and comments on manufacturing methods.)

McCambridge, W. F., Nagel, W. P., and Kowal, R. J.
FOREST INSECT CONDITIONS IN THE SOUTHEAST DURING 1957. Southeast. Forest Expt. Sta. Paper 93, 10 pp., illus.
(Discussion of survey and control activities.)

McCormack, J. F.
1957 PULPWOOD PRODUCTION IN THE SOUTH. Southeast. Forest Expt. Sta. Forest Survey Release 53, 16 pp., illus.
(Production of round pulpwood and pulp chips from wood residues by pine and hardwood species groups, by state; also production of roundwood by county.)

McCormack, J. F.
VIRGINIA'S FOREST RESOURCES. Va. Forests XIII(2): 4-7, 18-19.
(Report on the second Forest Survey of the State presenting current information on ownership, condition of forest land, timber supply, and trends since 1940.)

McGregor, W. H. D., and Kramer, P. J.
SEASONAL TRENDS IN THE RATES OF PHOTOSYNTHESIS AND RESPIRATION OF LOBLOLLY PINE AND WHITE PINE. (Abs.) Plant Physiol. 33(Sup.): XXVI.
(Rate of photosynthesis reached a peak in September; respiration rate for loblolly pine increased throughout the year. White pine respiration rates increased as plants grew, dropped when growth ceased, and increased again during winter.)

McLintock, T. F.
HARDPAN AND ROOT PENETRATION IN THE SPRUCE-FIR FORESTS. Soc. Amer. Foresters Proc. 1957: 65-66.
(Nonindurated sand-silt hardpans underlying spruce-fir forests of Maine are practically impervious to water and tree roots.)

Martindale, D. L.
SILVICAL CHARACTERISTICS OF SWEETGUM. Southeast. Forest Expt. Sta. Paper 90, 14 pp., illus.
(Extent and climate of botanical range, edaphic and physiograhic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Matthews, F. R., and McLintock, T. F.
EFFECTS OF FUNGICIDES ON POLLEN GERMINATION OF SLASH AND LONGLEAF PINE. Southeast. Forest Expt. Sta. Res. Note 122.
(At concentrations used in sprays for cone rust, and also at lower concentrations, captan and Basi-cop depressed pollen germination, Puratized prevented it, and ferbam increased it.)

Merkel, E. P.
DIORYCTRIA CONE MOTH ATTACK AS RELATED TO CONE RUST OF SLASH PINE IN NORTH FLORIDA. Jour. Forestry 56: 651.
(Rust-infected cones appear indirectly responsible for additional heavy losses in second-year cones by providing favorable breeding place for cone moth larvae.)

Metz, L. J.
THE CALHOUN EXPERIMENTAL FOREST. Southeast. Forest Expt. Sta., 24 pp., illus.
(Location, history, and research program of Calhoun Experimental Forest—a program aimed at rehabilitation of depleted Piedmont soils.)

Metz, L. J.
MOISTURE HELD IN PINE LITTER. Jour. Forestry 56: 36.
(Pine litter in a 12-year loblolly plantation had a low water-holding capacity, but served importantly in reducing raindrop impact and overland flow.)

Nelson, R. M., and Bruce, David
FOREST FIRE RESEARCH NEEDS IN THE SOUTH. Jour. Forestry 56: 399-403.
(Describes what and why fire research is needed.)

Nienstaedt, H., Cech, F. C., Mergen, Francois, Wang, C. W., and Zak, Bratislav
VEGETATIVE PROPAGATION IN GENETICS RESEARCH AND PRACTICE. Jour. Forestry 56: 826-839.
(Factors affecting success of vegetative propagation and details of methods—grafting, rooting, and air layering—that seem to offer most promise with American species.)

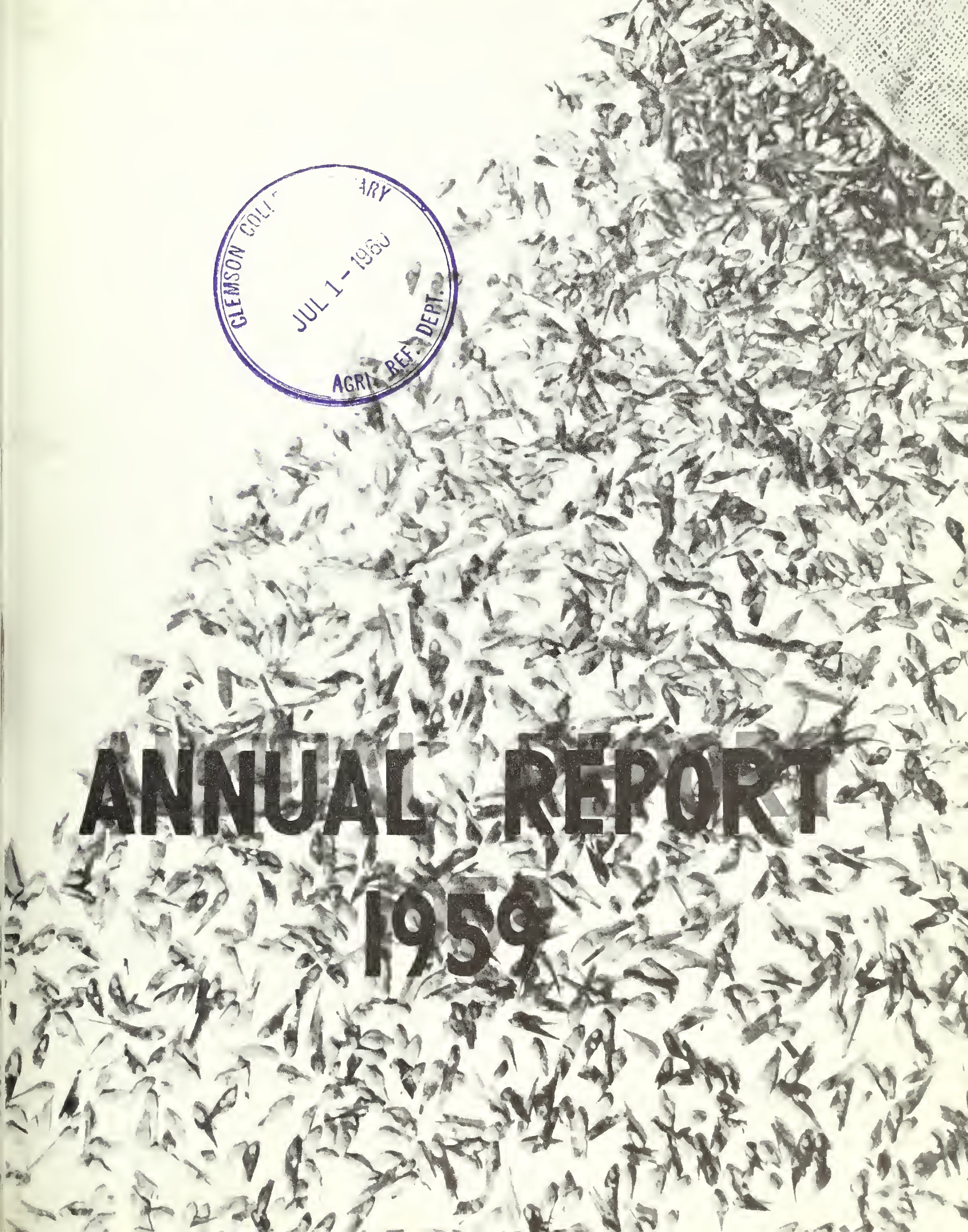
Ostrom, C. E., True, R. P., and Schopmeyer, C. S.
ROLE OF CHEMICAL TREATMENT IN STIMULATING RESIN FLOW. Forest Sci. 4(4): 296-306.
(Available evidence suggests sulphuric acid treatment does not increase rate of oleoresin synthesis, but serves chiefly to facilitate flow of oleoresin from resin ducts.)

Page, R. H.
RELATIVE EFFICIENCY OF FOUR STACKING METHODS IN AIR-SEASONING SOUTHERN PINE LUMBER. Forest Utilization Serv. Tech. Paper 1, 19 pp., illus.
(Evaluates rate of drying, uniformity of drying, and loss from seasoning degrade of four common methods of air-seasoning pine lumber in Georgia.)

Page, R. H.
WOOD PRESERVATION IN HOME CONSTRUCTION. Forest Utilization Serv. Release 19.
(Contains recommendations for protection of substructural members in dwellings vulnerable to decay and termite attack.)

Page, R. H., and Bois, P. J.
BUYING SAWLOGS BY WEIGHT. South. Lumber Jour. 62(7): 22.
(Advantages and disadvantages of buying pine sawlogs by weight in Georgia.)

SOUTHEASTERN FOREST
EXPERIMENT STATION



ANNUAL REPORT
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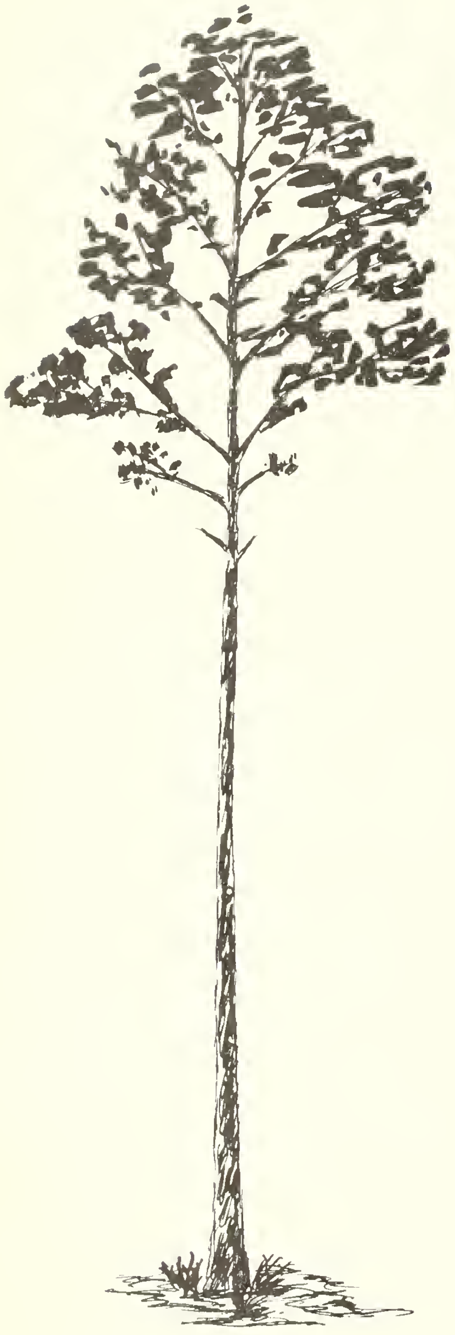


U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Southeastern Forest Experiment Station
Asheville, North Carolina

Joseph. F. Pechanec,
Director

CONTENTS

1959 Annual Report of the Southeastern Forest Experiment Station

FOREST MANAGEMENT

Intensification of forest management practices, expansion in forest tree nursery production, and increasing use of direct seeding within the Station's territory have created an interest and demand for research about forest tree seed. This interest involves greater knowledge of natural seed production, ways of producing more and better seed from superior parent trees, improved methods of handling, treating, and testing seed, and new and dependable means of obtaining adequate natural or artificial regeneration.

During 1959 we completed physical facilities, started programs, and finished a number of studies related to forest tree seed. Because of the interest and because many of our publications dealt with the subject, we have elected to emphasize "forest tree seed" as the major theme for this section of the annual report.

Work with forest tree seed embraces activities from basic physiology through applied research to pilot-plant tests and development. Such a span of activity means that publications provide only a partial measure of the results. An effort has been made in this report, therefore, to include work with forest tree seed which, although not always of a nature that warrants individual research publications, has helped materially to raise the level of forestry and forest production in the southeastern United States.

NATURAL SEED PRODUCTION

Knowledge of seed production in managed forest stands is essential before natural regeneration can be obtained consistently. During 1959, we reached some conclusions relating to loblolly pine seed production in the Virginia-North Carolina Coastal Plain, and shortleaf pine and oak seedfall in the Piedmont.

Loblolly Pine in the Virginia-North Carolina Coastal Plain

Twelve years of trapping loblolly pine seed in this area showed that seed crop size fluctuated from year to year in both uncut (fig. 1) and partially cut stands.

Stimulation of the seed source by preharvest release improved seed production, particularly in poor seed years. Stimulated, selectively cut stands of mature trees produced more seed than uncut stands of a similar age. Stimulated strips of seed trees and four or eight uniformly spaced seed trees per acre produced quantities similar to uncut stands.

Not only did stimulation improve seed production, but it also produced an increase in the percentage of sound seed (fig. 2).

Stand age is an important factor affecting seed production. Young forest-grown trees are generally unsatisfactory seed producers, unless stimulated by thinning or other preharvest release.

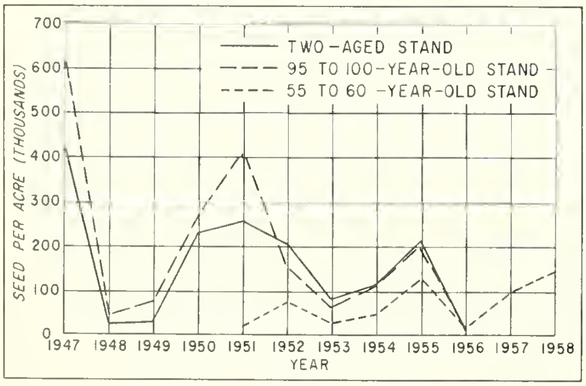


Figure 1.—Sound seed production in uncut mature loblolly pine stands in the Virginia Coastal Plain. A production level of 50,000 or more sound seed per acre occurred in 4 out of 8 years in a 55- to 60-year-old stand, 8 out of 10 years in a 95- to 100-year-old stand, and in 7 out of 10 years in a two-aged stand composed of 60- to 80- and over 100-year-old forest grown trees.

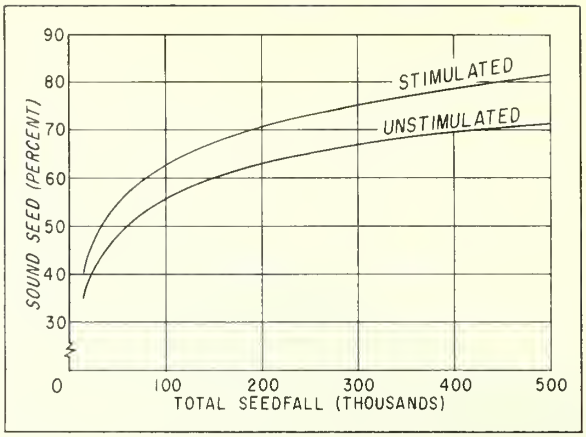


Figure 2.—Relationship of soundness with loblolly pine seed crop size and effect of stimulation. These data show that the relationship between seed crop size and percentage of sound seed is logarithmic instead of linear, as previous work had indicated.

Shortleaf Pine in the Piedmont

Additional evidence is accumulating which indicates that shortleaf pine is an erratic seed producer. Observations show that in five years a seed crop of 50,000 seed per acre or more has occurred only once at Union, South Carolina, twice at Morganton, North Carolina, and Clemson, South Carolina, and three times at Athens, Georgia.

Reliable estimates of cone crop would allow for adjustment of cutting plan to take advantage of good cone and seed crops and for effective seed collection plans. An estimating method has been developed for the Virginia Piedmont by the Charlottesville Branch.

This estimate is based on the ratio of conelets to cones in portions of the top of felled dominant or codominant trees. The number of conelets in the crop a year hence is then reduced by 55 percent and expressed as a multiple of the current crop.

Regeneration of natural shortleaf pine stands in the Virginia Piedmont has been recognized as one of the most important forest management problems in that region. All too often the failure to get adequate natural regeneration can be traced to either a lack of seed or its inability to germinate. Consequently, increased emphasis on shortleaf pine seed production and seedbed requirements has been incorporated into our research program.

Oak Seedfall in the Piedmont

Knowledge of acorn production is still principally in the sampling and trapping techniques stage (fig. 3). However, oak seedfall studies in the North Carolina Piedmont indicate that the 1959-60 acorn crop is the largest in 3 years. Almost three times as many acorns were trapped through early November 1959 as were collected during the entire collection period of the previous year. Scarlet oak outproduced white oak and black oak, and yielded a larger proportion of sound acorns (32 percent) than either white or black oak. A few individual trees of each species continue to stand out as excellent producers, although we have not been able to accurately tie down the factors associated with high production.

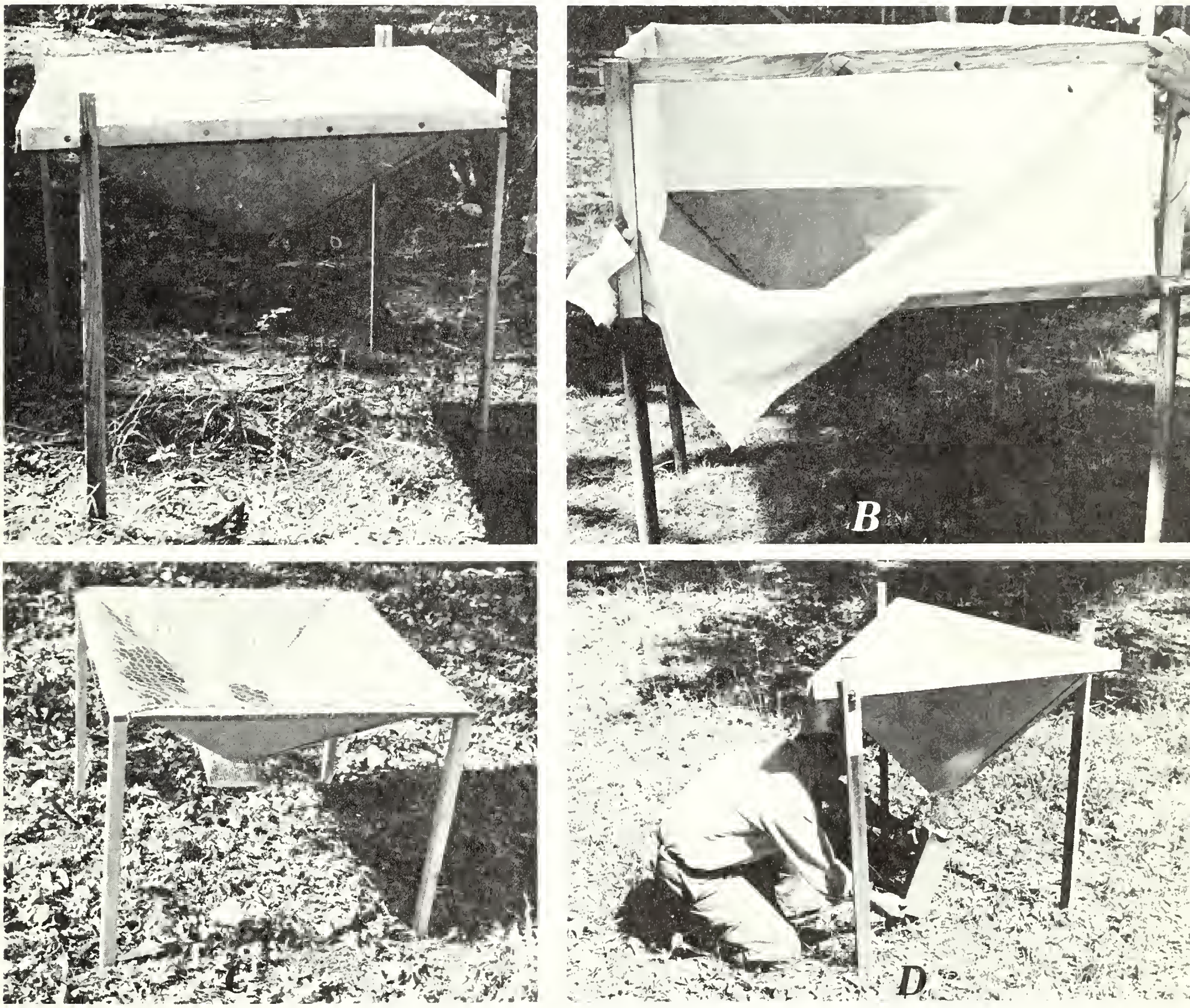


Figure 3.—Satisfactory seed traps for light-seeded pines and hardwoods have been available for a number of years, and the paper trap shown in *A* was described by Charleston Research Center personnel as early as 1951.

Sampling heavy-seeded oak and hickory has presented problems in trap design. One of the problems is the tendency for a high proportion of acorns and nuts to bounce out of standard traps. Three ideas have been developed by research personnel for restricting this bias. At Athens, Georgia, a buffer was constructed around the top of the trap (*B*). At Statesville, North Carolina, a burlap layer was strung across the mouth of the trap to reduce resilience (*C*). The triangular trap shown in *D* is an adaptation of the trap shown in *A*. The steeper angles deflect the seed to the bottom of the trap and practically eliminate loss from rebound.

Figure 4.—General view of part of a 5-acre slash pine seed orchard recently established at Lake City, Florida. This orchard contains 9 clones of the F_1 progeny of high gum-yielding trees. Irrigation is provided by pumping water into ditches between the rows.

PRODUCING MORE AND BETTER SEED

Seed From Superior Trees

In the Southeast, recent emphasis in forest tree improvement has been placed on wood quality, particularly with the southern pines. Immediate objectives of this work have been to distinguish the effect of environmental factors; to determine what and how much variation exists within trees, between trees, and between races; and to develop techniques for estimating wood quality. The Station's contribution to this field might best be illustrated with some examples of work now under way or completed in 1959.

In cooperation with the Forest Utilization Research Division, wood quality tests are being made on both the selected clones used in the Georgia Forestry Commission seed orchards and on the high gum-yielding strains developed at Lake City. Also, loblolly pine seed-source study material at the Lee Experimental Forest in Buckingham County, Virginia, will undergo specific gravity tests. The Forest Products Laboratory is analyzing samples taken by the Forest Survey throughout Florida and Georgia from all natural softwood pine species except cypress to determine the variation in wood specific gravity.

Wood quality characteristics, so important to pulp, paper, and other wood products, vary widely within species, and it is possible to select strains with certain desirable characteristics. Such things as tracheid length, cell wall thickness, specific gravity, fibril angle, and cellulose content affect pulp yield and strength qualities. A summary of studies in variation and inheritance of wood quality factors in southern pines has been prepared by Dorman (see bibliography). It indicates that the field of wood quality should receive greater emphasis when breeding for high gum yield, good form, and resistance to insects and disease.

A major development during the past year has been the attempt to combine high gum yield with other desirable traits in slash pine, especially rapid growth rate and high specific gravity. Gum yield is heritable to a rather high degree (heritability about 45 to 62 percent) and seed orchards are now being established to make use of the findings (fig. 4).

Combining high gum yield with other traits can be done in several ways. One way is to select for growth rate and specific gravity among progenies of high gum-yielding parents. In this case, growth rates and specific gravity of 14-year-old progenies have already been measured and heritability estimates of these traits are being made. A fair amount of variation is present, and the next step will be to make the selection and estimate possible gains. The trees having the highest degree of superiority in all three traits will be used as clonal stock for seed orchards if estimated gains warrant it.

Another method of combining traits is to cross trees selected for superiority in individual traits. Pollen is being collected from trees selected for superiority in gum yield, high specific gravity, and rapid growth, and will be mixed and applied to female flowers of each selection. These crosses will provide a progeny test of each selection, but some first-generation individuals superior in all three traits should result from the multiple matings. Such superior individuals will be used in clonal seed orchards and for further breeding.

Finally, one other approach is to establish a special type of seed-production area. A preliminary selection is first made in a young plantation on the basis of growth rate, specific gravity, and gum yield, and all undesirable trees are removed. The selected trees serve as an immediate source of seed for a modest gain. However, further work could also include eventual progeny testing of the selected trees with wind-pollinated seed. These tests will be the basis for further selection and thinning or for establishment of clonal orchards to produce seed for trees with high growth rates, specific gravities, and gum yields.

Seed Source Studies

Slash pine.—Slash pine seed-source studies in Georgia and Florida suggest that seasonal distribution of rain and length of growing season are instrumental in causing natural selection for variation found in growth rates. That portion of the species range where the climate is optimum appears to produce trees with higher growth rates, even when these trees are planted in other portions of the natural slash pine range.

A heterogeneous population of trees in this optimum climatic zone probably selects for superior growth rate among the trees themselves. The more rapidly growing trees will, on the average, dominate in greater numbers and produce the next crop, eventually resulting in trees which are inherently superior in growth rate.

On the other hand, trees at points progressively further away from this optimum climatic zone will favor other traits, probably those associated with survival. For example, in progressing northward, colder winters may cause more rigid selection for resistance to frost, with less stringent selection for rapid growth. The same could be true for rainfall at critical periods.

Thus, these tests suggest clinal variation deviating from what may be the "heart" of the species range. They also suggest that use of local seed may not always be the best policy and that seed collected from an apparently optimum zone may be made moderately superior even when planted in other climates with no great loss in survival. These early results may change as the test trees grow older, but if they hold, we may be able to deviate somewhat from the usual "local seed rule" to obtain a modest genetic improvement in slash pine by wise choice of seed sources.

Loblolly pine.—Among the plantings from 166 southern pine seed-sources in several studies at the George Walton Experimental Forest near Cordele, Georgia, are nine loblolly pine sources from seven states (table 1). Fifth-year results show that height growth decreases with decreasing average annual temperature. Incidence of southern fusiform rust did not vary with seed source. Also, there was little correlation between rate of height growth and incidence of fusiform rust, a relationship often suggested. No evidence of differences in susceptibility to Nantucket pine tip moth or pine webworm were evident.

Analysis of studies of racial variation at an early age may lead to erroneous conclusions if growth patterns change before the trees reach merchantable size. Height of stock from the three southernmost latitudes showed the same relative superiority in height over stock from the northernmost latitude after 5 years in the field as it did at 1 and 3 years.

Longleaf pine.—Fifth-year results of longleaf pine seed-source studies at Cordele have shown significant differences in height growth among sources. For example, a coastal plain source in Alabama (Baldwin County) averaged 2.2 feet taller than a piedmont Alabama source (Cleburne County). Stock from two sources in Louisiana had significantly less height growth than Georgia stock, but east

Texas stock did not. Survival was not affected by location of the seed source (table 2).

Table 3 summarizes the principal results of the Nansemond County, Virginia, installation of a north-south longleaf pine seed-source study after 6 years in plantation. Highly significant differences in survival and height growth are apparent between the most southern source and those farther north.

Seedlings from the Hillsborough County, Florida, source were damaged by severe frosts November 30 through December 3, 1958, when a series of freezing temperatures dropped to as low as 15° F. Figure 5 shows the resultant top kill. The tallest trees were damaged most severely. Some died; others put out new shoots which are still healthy.

The difference in height growth of the Florida source seedlings reflects frost damage, a general lack in vigor, and delay in coming out of the grass stage.

Yellow-poplar. — Yellow-poplar seedlings from sixteen geographic sources were planted in 1954 in a seed-source study on the Bent Creek Experimental Forest near Asheville, N. C. The sources ranged from southern New York and southern Michigan to northern Georgia and northern Mississippi.

Table 1.—Average seedling height and fifth year survival by temperature zone and latitude of seed source.

Seed source	Temperature zone	Latitude	Height			Survival
			1 year	3 years	5 years	
	Degrees F.	Degrees N.	- - - - Feet - - - -			Percent
Livingston Parish, Louisiana	67	30.4	0.76	3.3	9.3	79
Crisp and Wilcox Counties, Georgia	67	31.7	1.01	3.7	9.3	80
Onslow County, North Carolina	62	34.7	.84	3.3	9.0	74
Pamlico County, North Carolina	62	35.0	.85	3.4	8.7	84
Angeline County, Texas	67	31.1	.83	3.3	8.7	85
Cullman County, Alabama	62	34.1	.90	3.5	8.1	86
Jefferson County, Alabama	62	33.6	.83	3.1	7.8	85
Clark County, Arkansas	62	33.6	.91	3.1	7.8	92
Somerset County, Maryland	57	38.1	.74	2.9	7.8	87

Table 2.—Average height and survival after five growing seasons in longleaf pine seed source study at Cordele, Georgia.

Source	Average height	Source	Survival
	Feet		Percent
Baldwin County, Alabama	9.0	Baldwin County, Alabama	88.8
Treutlen County, Georgia	8.7	Cleburne County, Alabama	84.7
Polk, Tyler, and Hardin Counties, Texas	8.0	Rapides Parish, Louisiana	84.2
Washington Parish, Louisiana	7.7	Polk, Tyler, and Hardin Counties, Texas	82.6
Cleburne County, Alabama	6.8	Washington Parish, Louisiana	81.1
Rapides Parish, Louisiana	6.2	Treutlen County, Georgia	74.0

Although early height growth was confounded by deer browsing, growth initiation at the Bent Creek location still has retained the characteristics of the seed-source origin. The shorter the growing season at the seed-source origin, the later growth began in these tests (fig. 6).

In addition, morphological differences were apparent among the seed sources. Leaf shapes from a seed source near the eastern extremity of the range differed in lobe shape and depth of sinuses from those seed sources near the northwestern extremity (fig. 7). The pattern of these differences is being studied within seed sources to correlate physiological differences with noticeable morphological differences.

Table 3.—Six-year survival and height growth of longleaf pine in seed-source study in Nansemond County, Virginia

Seed source	Survival	Average height
	Percent	Feet
Rapides Parish, Louisiana	93.3	7.42
Harrison County, Mississippi	96.1	7.38
Treutlen County, Georgia	95.0	7.76
Nansemond County, Virginia	92.6	7.76
Hillsborough County, Florida	67.2	2.51

Figure 5.—Longleaf pine seedlings from Hillsborough County, Florida, in Nansemond County, Virginia, planting. These seedlings had less height growth and survival than more northern sources. They were frost damaged and showed a general lack of vigor.

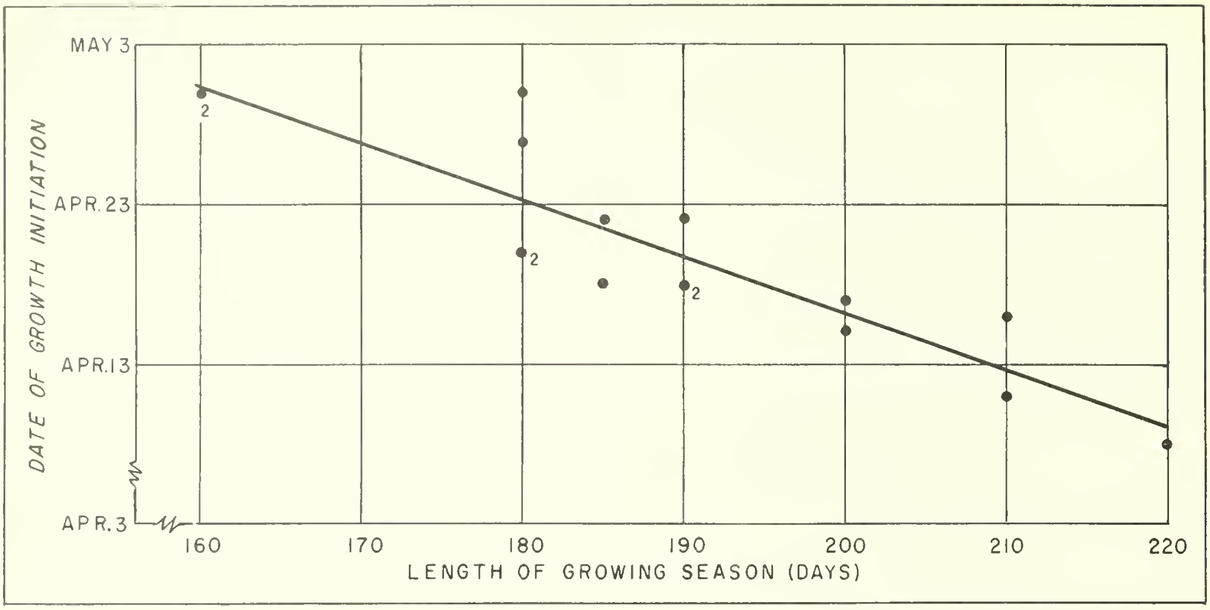


Figure 6.—Relationship of growth initiation to length of growing season at their origin for 16 different seed sources of yellow-poplar at Bent Creek Experimental Forest.

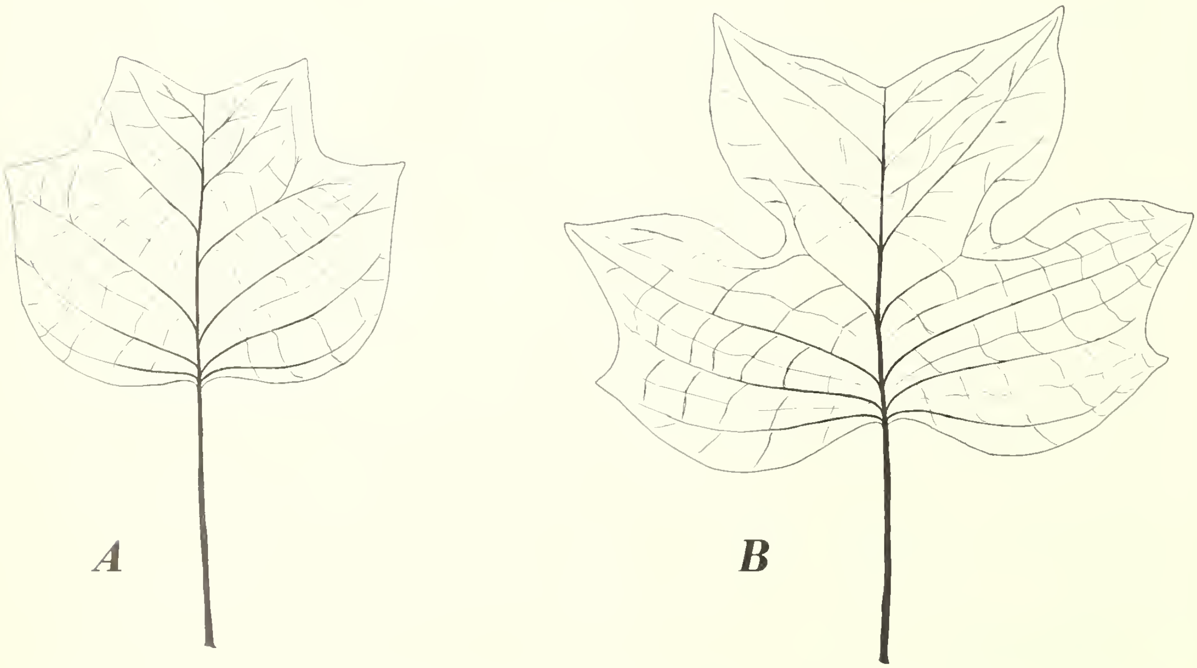


Figure 7.—Yellow-poplar seed-source study indicates differences in morphological characteristics among the seed sources. Note the difference in lobe shape and depth of sinuses between seed source from Wake County, North Carolina, (*A*) near the eastern extremity of the species range and Dexter, Indiana, (*B*) near the northwestern extremity of the range.

Physiology of Flowering

Studies of the physiology and biochemistry of tree flowering and seed production are being conducted in cooperation with Duke University. The exploratory approach to date has been to analyze parts of trees (especially buds, flowers, and conelets) to find the compounds or processes related to flowering and to discover pertinent differences in composition or processes between trees of different flowering potential.

Much of the past year was spent in developing satisfactory techniques for analyses of slash and loblolly pines. Methods for separating out terpenes and other resinous compounds, which occur in abundance in pines and which cloud identification of other organic compounds, have been developed. Specialized analytical techniques used in separation and identification of biochemical compounds are shown in figure 8, and radio-tracer techniques used to study processes in pine tissues are shown in figures 9, 10, and 11.

Seed Certification

In 1958, certification standards for forest tree seeds were accepted by the Georgia Crop Improvement Association. Since then, the time-consuming tasks of training inspectors, selecting trees in seed-production areas, establishing seed orchards, and setting up progeny tests (figures 12 and 13) have been under way. It will be possible, beginning in the fall of 1960, for a Georgia producer to market seed bearing the blue tag "Certified Seed" of the Georgia Crop Improvement Association.

During 1959, South Carolina, drawing upon Georgia's experience, enacted and put in operation legislation for certifying forest tree seed.

FROM EXTRACTION TO PLANTING

Seed Research

The new Seed Testing Laboratory at Macon, Georgia, sponsored by the Georgia Forestry Commission, the Georgia Forestry Research Council, the Southern Region of the U. S. Forest Service, and the Southeastern Forest Experiment Station, does service testing of seed besides seed research (fig. 14). Three phases of seed research during the past year yielded recommendations for cone and seed handling.

The deterioration of seed in air storage while waiting extraction and cleaning varies with species. Data obtained during the past year confirmed previous indications that longleaf pine is sensitive to prolonged air storage (fig. 15). Loss in viability is greater with longleaf than with slash pine. In the operation of cone extractories, it is suggested that longleaf be extracted as soon as the cones are opened.

Each year more forest tree seed is treated with bird and rodent repellents in direct seeding and in nursery plantings. Common latex stickers used in repellent treatments adversely affect seed germination; water uptake by the seed is restricted. To overcome this germination delay, the following steps have been found effective:

1. Test the seed before and after stratification but prior to application of the sticker and repellent chemical.
2. If stratification depresses either the rate or the total germination, use unstratified seed with the repellent treatment. The germination rate will be slowed, although the total germination will usually not be affected.
3. If stratification does not depress germination, the seed should be stratified prior to application of the sticker and repellent chemical. Stratification prior to application of the sticker will result in fully imbibed seeds and make it possible for germination to begin. The delaying action of the sticker will be minimized.

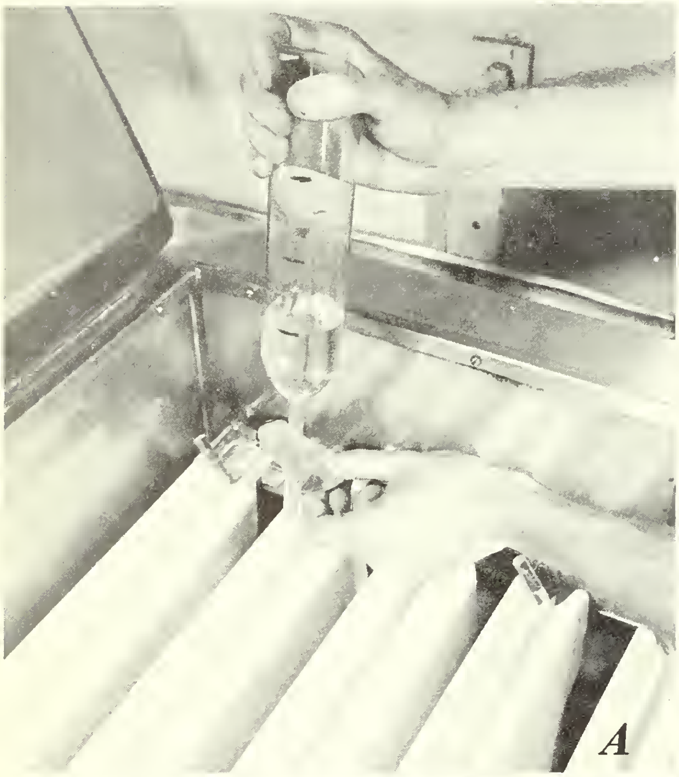
Seed Physiology Research

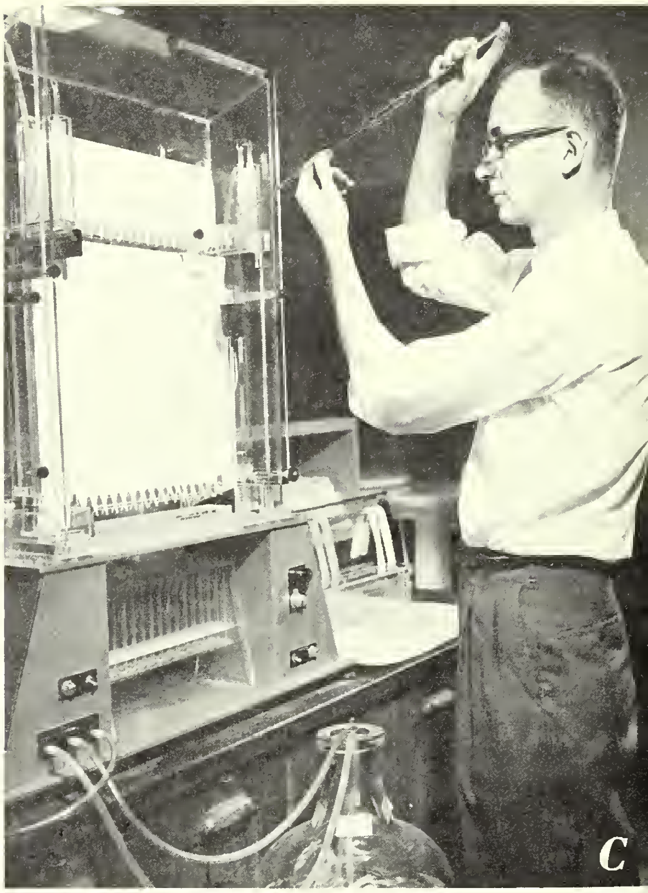
In addition to building seed-testing research facilities at Macon, Georgia, a seed physiology project has been housed and partially equipped during the past year and the program of the project has been developed. In addition to studies of damage during seed extraction and handling (fig. 16) and carbon nitrogen metabolism in pine embryo in isolated cultures, the following fields have been included in the project's scope:

1. Changes in the amino acid and sugar contents of pine seed during storage, stratification, and germination.
2. Changes in the nucleic acid and protein

contents of pine seed during germination.

3. Phosphorus and sulphur metabolism in germinating pine seed.
4. The activity of mitrochondria during germination.





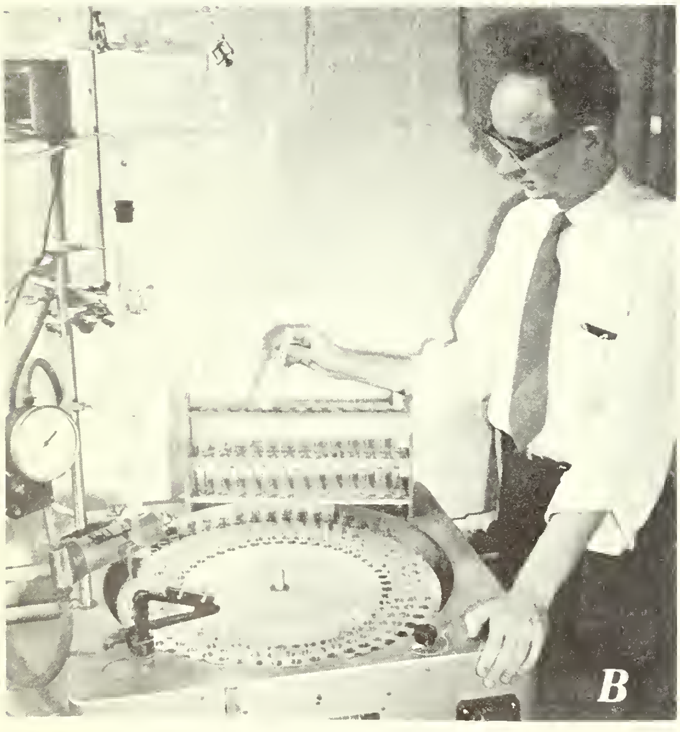


Figure 8.—Research in the physiology of flowering uses a number of methods to separate biochemical compounds; *A* illustrates a step in the two-dimension paper chromatography technique —a basic method used in identification and analysis of compounds in pine tissues. Complex mixtures are separated into individual compounds which appear as discrete spots on finished chromatograms. The step shown here involves adding the developing solvent to trays containing chromatograms.

B shows an ion-exchange column being used with an automatic fraction collector to separate amino acids in extracts of pine tissues. This technique handles much larger samples than does paper chromatography. Various amino acids wash through the resin column at different speeds and are collected in different test tubes.

Paper electrophoresis (*C*) is a technique used to separate compounds. An electrical potential maintained across the filter paper screen separates compounds according to their movement in the electrical field.

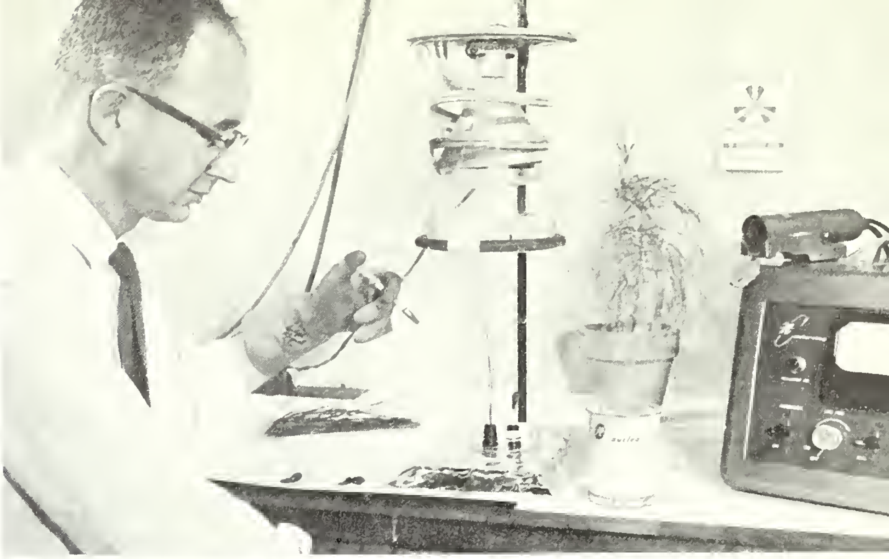


Figure 9. — Feeding radioactive amino acid solutions to loblolly pine needles and conelets to study physiological processes. Radioactive compounds formed in the tissues are identified by paper chromatography and autoradiography.

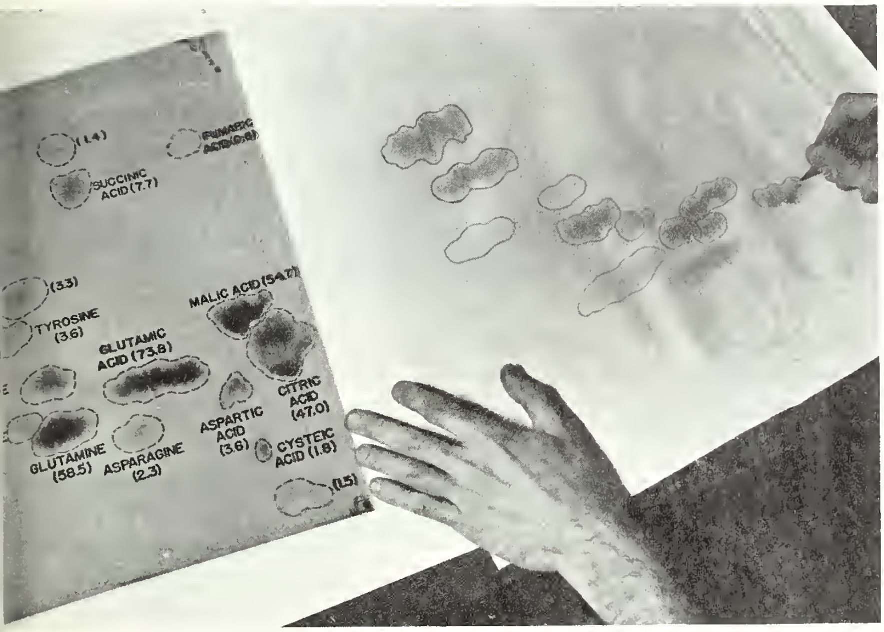


Figure 10.—Finished chromatogram (*right*) and autoradiogram (*left*) of pine needle extracts. The spots on the chromatogram were made visible by spraying the paper with a chemical reagent which reacts with amino acids. The spots are identified by the positions which they occupy on the chromatogram.

The autoradiogram is a sheet of X-ray film which has previously been placed in contact with a paper chromatogram and on which the compounds formed in a radiotracer experiment have been separated. The locations of radioactive compounds are revealed by the darkening of the X-ray film where it has been in contact with radioactive spots.

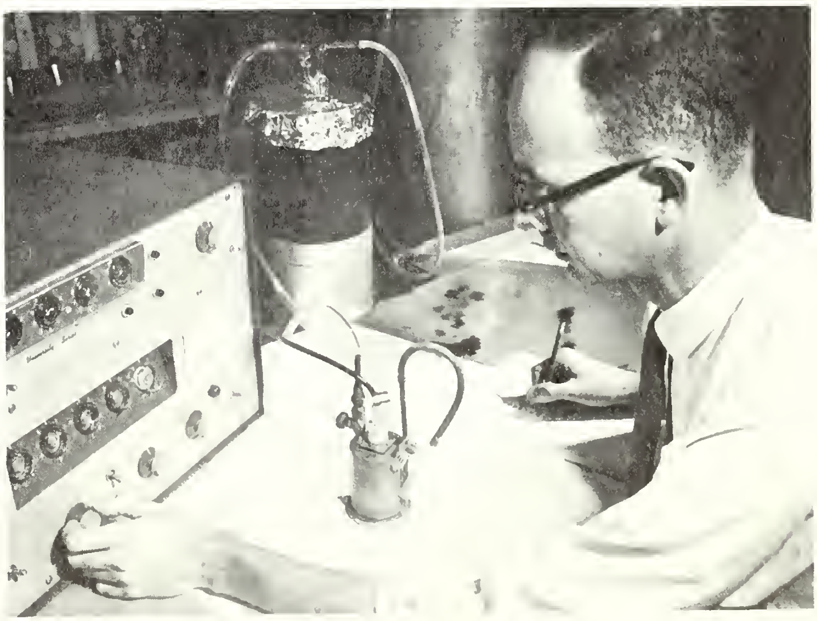
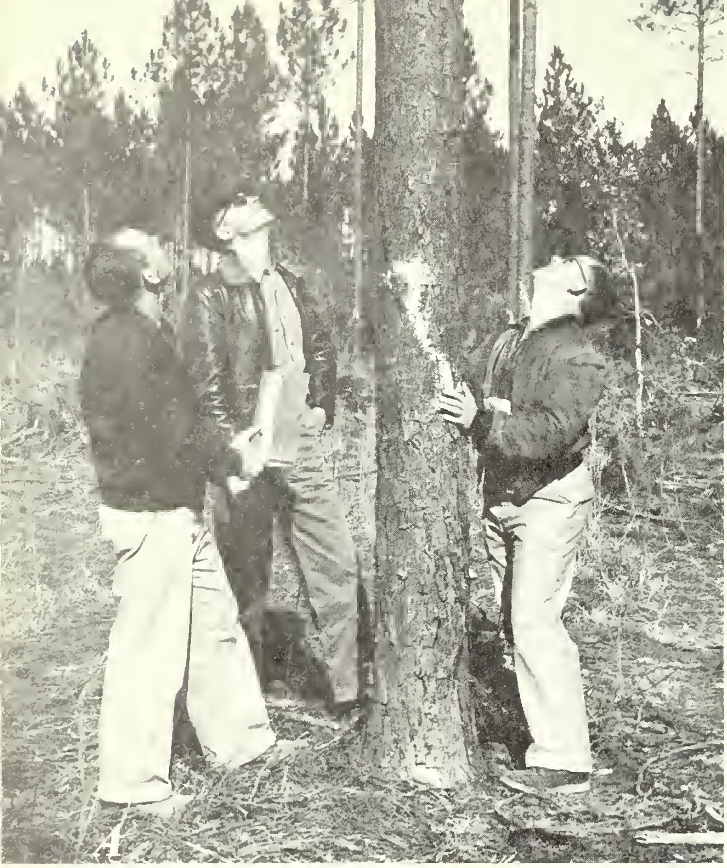


Figure 11. — Determining the amounts of radioactivity in compounds formed in pine buds during a radiotracer experiment. Radioactive compounds, which have been located by autoradiography with X-ray film, are counted by means of the Geiger tube (*center foreground*) connected to the scaling unit on left.



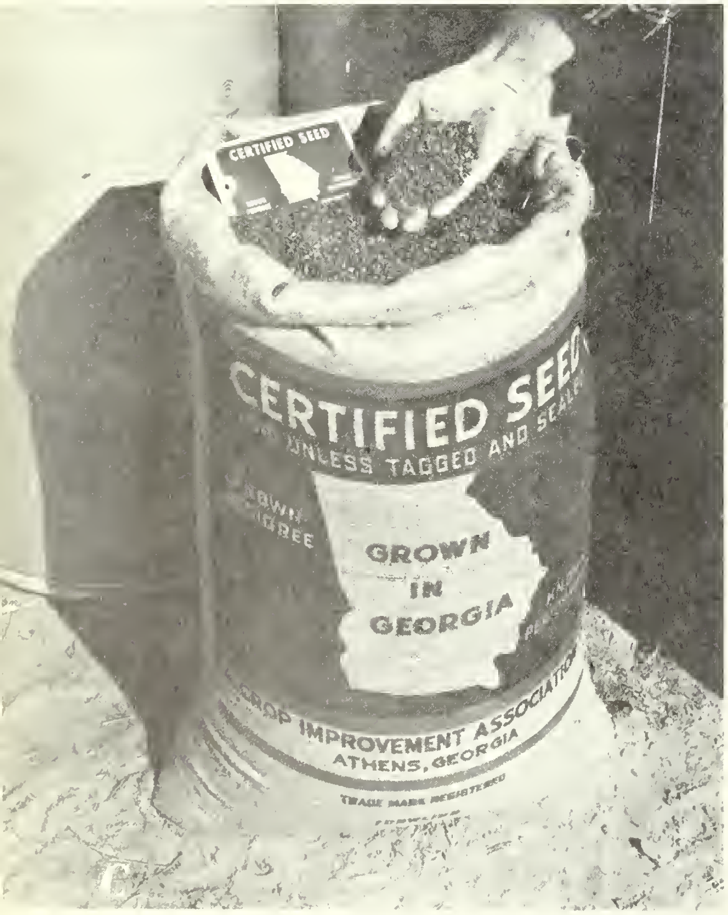
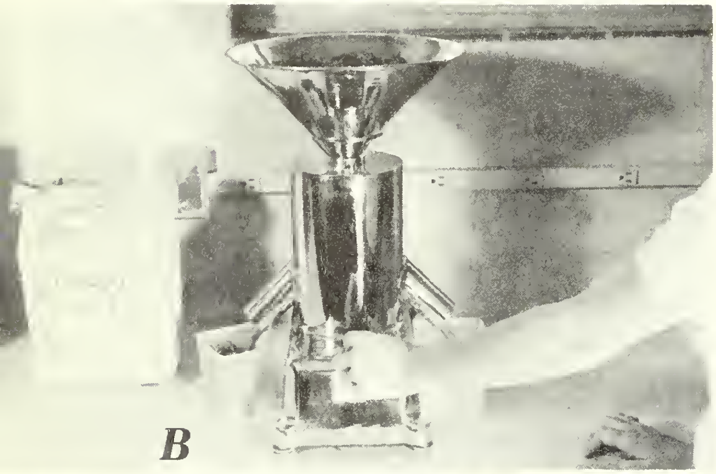
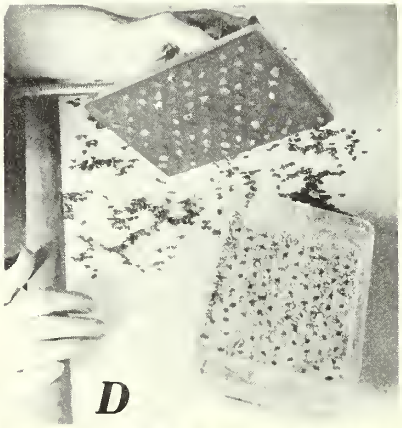


Figure 12.—After seed certification standards are devised, it is necessary to train inspectors and select seed-production areas. *A* shows examination of a tree on the first seed production area approved for certified seed. An over-all view of a portion of this area, owned by Continental Can Company in Emanuel County, Georgia, is shown in *B*. Certified seed (*C*) is the ultimate objective of the entire program.

Figure 13.—To establish seed orchards it is necessary to prepare root stocks (*A*) for grafting with scions from superior trees (*B*). The grafted stock is then outplanted in seed orchards (*C*), after which it grows rapidly. The material in *D* was field planted in the fall of 1955 by the Georgia Forestry Commission with technical assistance by the Macon Research Center. Here it is shown after 4 years in the field.





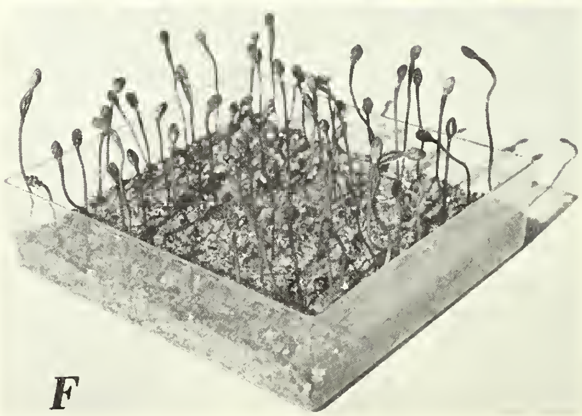


Figure 14.—The Seed Testing Laboratory at Macon, Georgia, (*A*) has both seed testing and seed research facilities, including (*B*) devices to mix and divide seed samples, (*C*) seed preparation equipment and facilities, (*D*) vacuum seed counters, and (*E*) germinating rooms with controlled temperature and humidity. A high degree of control can be maintained and accurate germination tests are the result (*F*).

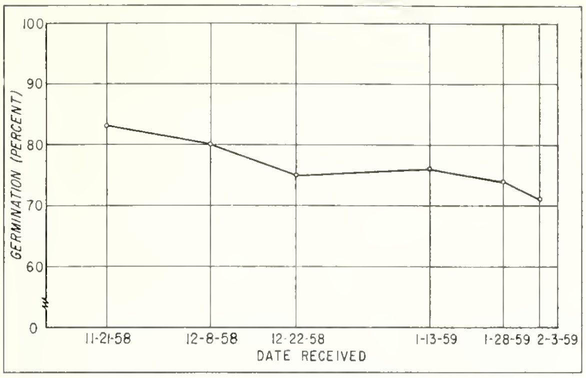
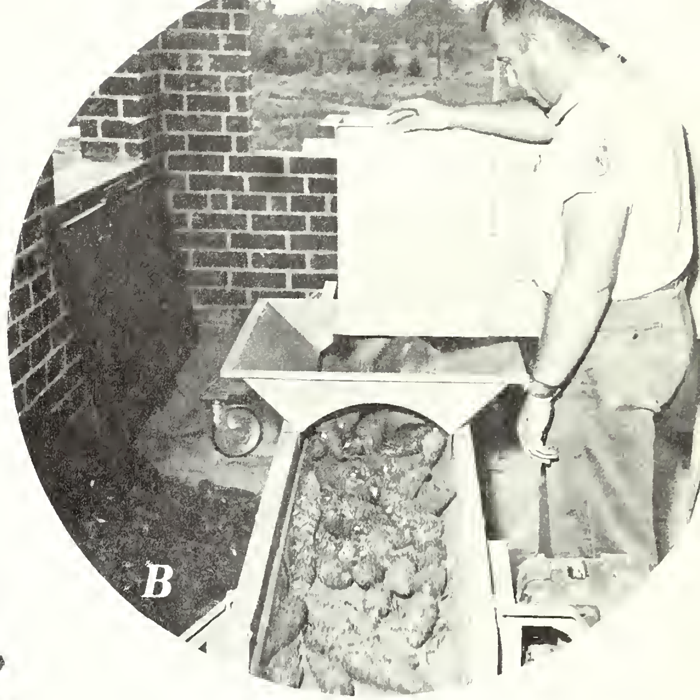


Figure 15.—Germination percent of longleaf pine seed as related to time of extraction. The date of receipt at the seed laboratory is correlated with the time of extraction of late seed; i.e., late sample receipt means late extraction at the nursery.



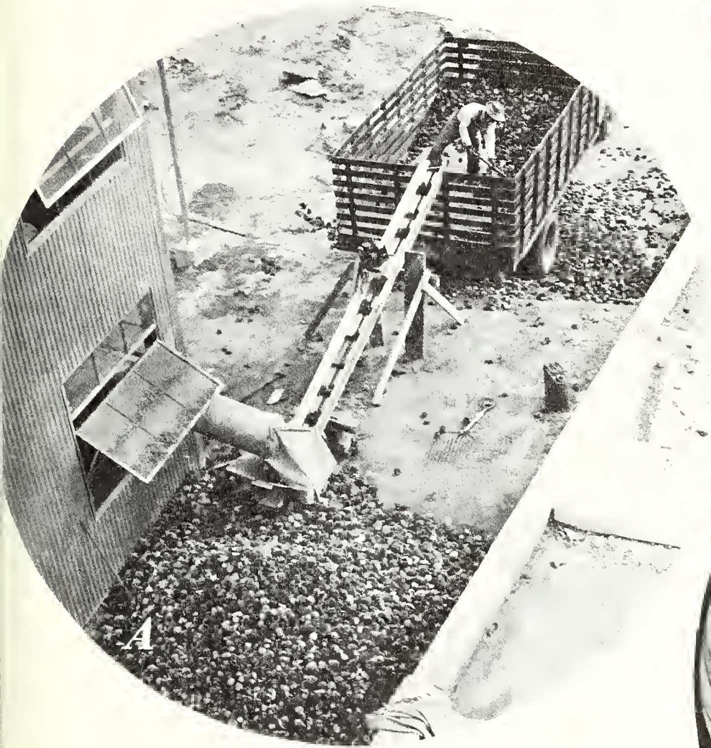
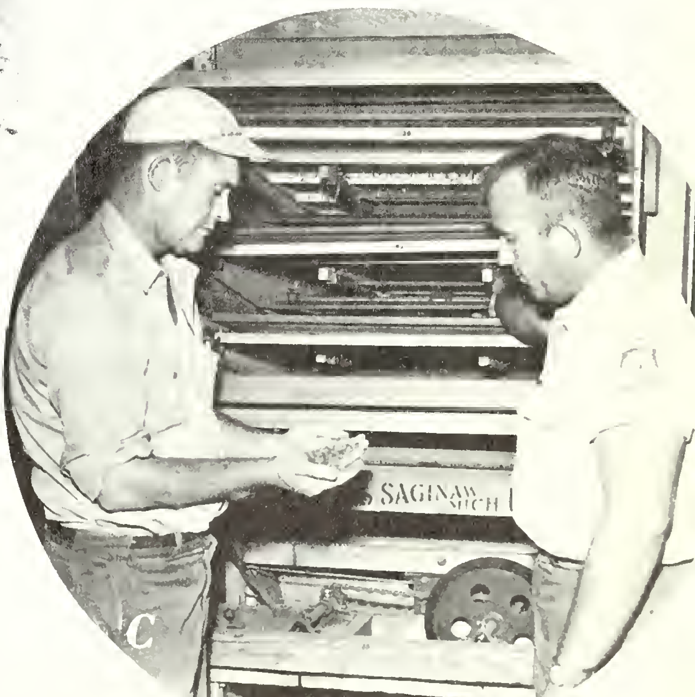


Figure 16.—Seed handling research. Germination is often reduced during seed extraction and handling, but the reasons for this reduction are not known. Some damage may be caused prior to drying (*A*) or during the extraction process (*B*), (*C*), especially by dewinging and cleaning action. Further reduction in germination occurs between the completion of the extraction process and actual planting of the seed.



PROGRESS IN USE OF SEED

Direct Seeding Slash Pine

Test areas in Collier County, Florida, were direct seeded to slash pine. This cutover pine land had a typical growth of sawpalmetto, gallberry, and wire grass. Part was chopped with a Marden brushcutter prior to planting and part was left in a natural condition.

Site preparation did not successfully affect seedling establishment or seedling growth up to 2 years under moderately dense cover conditions. Differences between three direct seeding rates, however, were highly significant (fig. 17)

In the south Florida area, on flatwood sites where the sawpalmetto cover is light to only moderately dense, site preparation is not required for the establishment of a stand of slash pine by direct seeding. However, where the sawpalmetto cover is dense (i.e., where the sawpalmetto has crowded out the wire grass) site preparation will be required for seedling establishment, fire hazard reduction, and to facilitate later cutting operations in the stand.

Early Planting of Slash Pine

Trials of early planting of slash pine near Lake City, Florida, show promising results. The normal planting season in this area is in the late fall and winter months. A study encompassed planting in summer and in winter to measure survival following earlier season planting.

Part of a group of seedlings grown from seed sown in March 1958 were outplanted in August 1958, and the remainder were outplanted in December 1958. Field survival and growth are shown below:

Outplanting (Date)	*Survival* * (Percent)	*Height at time of planting* (Feet)	*Height by July 1959* (Feet)	*Height growth* (Feet)
Aug. 20, 1958	80	0.95	1.42	0.47
Dec. 16, 1958	80	.98	1.23	.25

* As of July 1959.

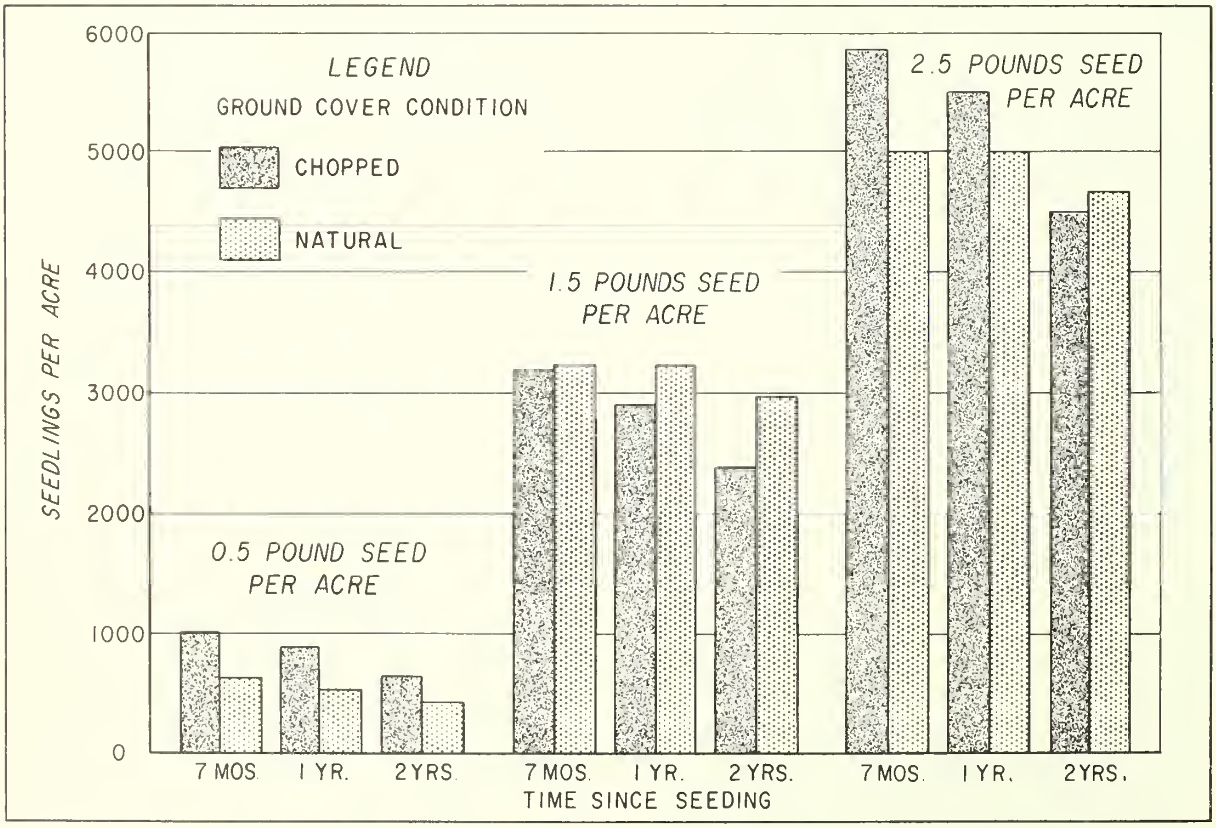


Figure 17.—Establishment of slash pine seedlings from seed in south Florida, sowed at three rates and with site preparation.

Satisfactory survival was obtained from late summer planting and the results suggest that the planting season might be altered. Success of the early planting may be explained by the fact that although summer temperatures are generally higher than winter temperatures, the amount of rainfall is usually higher and distribution better in summer than in winter in north Florida.

Seedlings planted in August 1958 stopped growing after outplanting, but then more than made up for this loss in the following spring. By July 1959, the trees planted earlier were taller than those planted at the usual time. Apparently, the seedlings planted early had become well established before the next growing season and had built up higher reserves of stored food for growth the following year.

Direct Seeding Bottom Land Oaks

Since 1952, studies in the direct seeding of cherrybark oak and Shumard oak have been under way at the Charleston center. Direct seeding showed definite promise under certain site conditions (table 4).

Seeding success can be improved by reducing the number of unsound acorns either by visual inspection (fig. 18), by hot water baths, or by fumigation before planting.

Effectiveness of seeding can be further improved by decreasing rodent depredations. Current studies are testing the use of various repellents on seed predators (fig. 19).

Table 4.—Average third-year survival and height growth of direct seeded oaks by site condition, Santee Experimental Forest [1]

Species	Cleared terraces		Released first bottoms [2]	
	Survival	Total height	Survival	Total height
	Percent	Inches	Percent	Inches
Cherrybark oak	23	23	5	13
Shumard oak	37	30	6	28
Average	30	27	6	20

1/ Summary of 1953, 1954, and 1955 study installations.
2/ Released after one growing season.

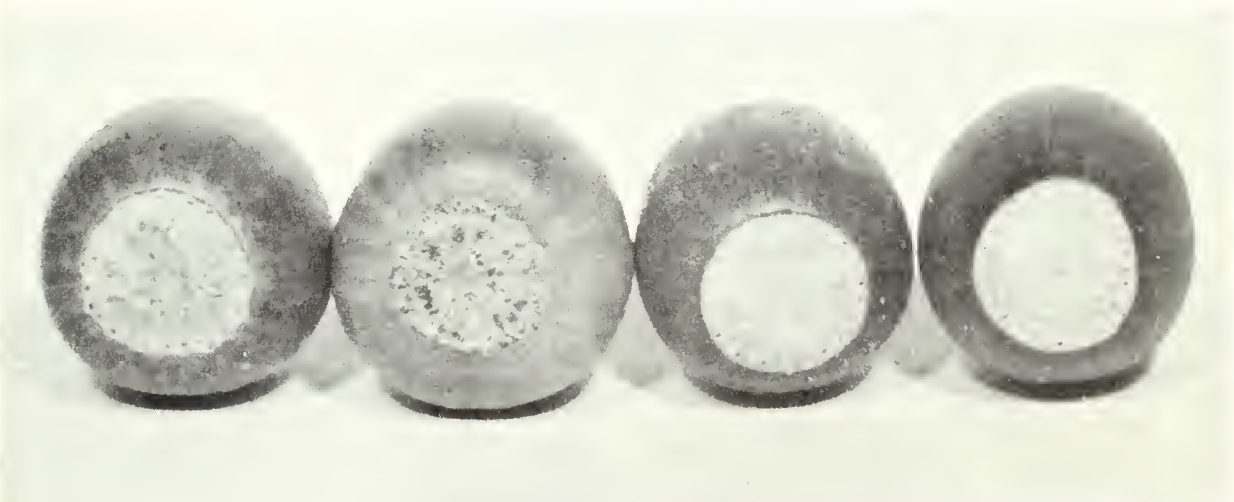
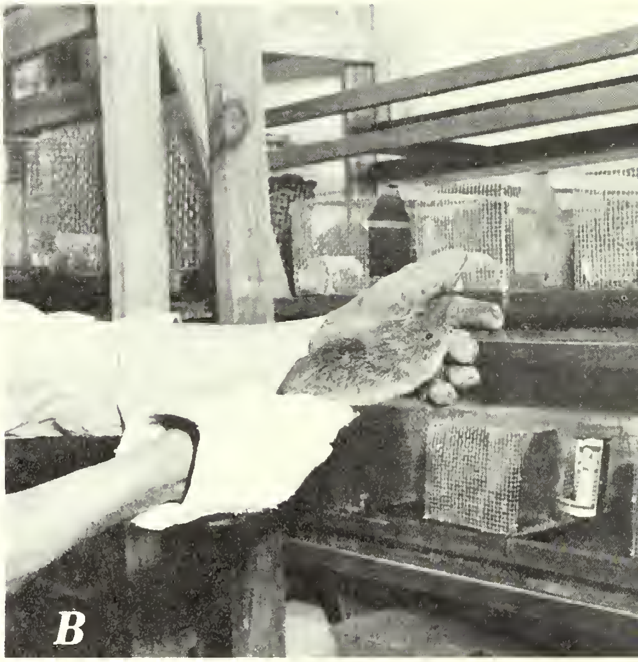


Figure 18.—Shumard oak acorns. Those with light colored cup scar (2 on right) are sound, and those with dull coloration (2 on left) show evidence of weeviling or rot.



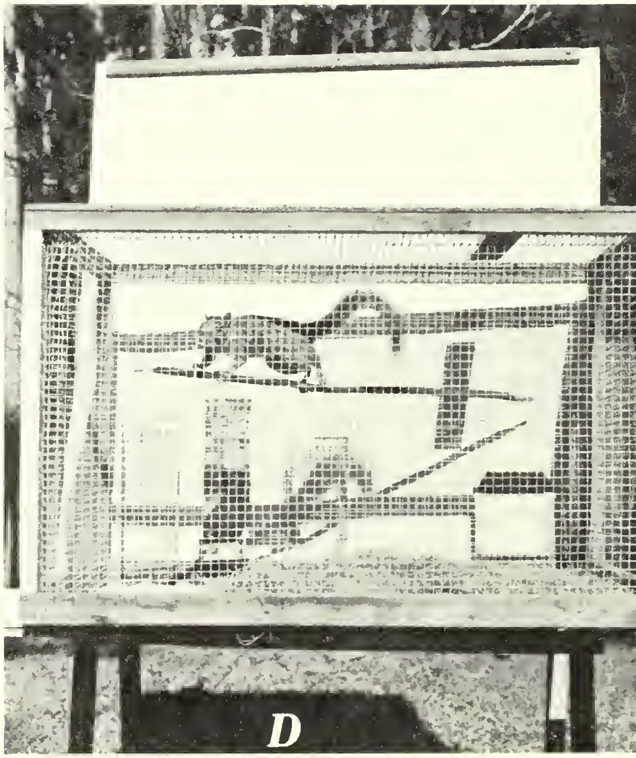


Figure 19.—To test reactions to various repellents applied to bottom land oak acorns, mice (*A*), cotton rats (*B*), and squirrels were trapped on the Santee Experimental Forest. *C* shows a squirrel becoming accustomed to corn bait. The feeding tests are carried on in large cages (*D*).

Direct Seeding Upland Oaks

Two tests of upland oak direct seeding were made in the Piedmont and mountains of North Carolina. In the Piedmont, white oak acorns were planted in the fall, and black and northern red oak acorns were stratified and the sprouted acorns planted in the spring. Screening helped survival, although no appreciable predator loss occurred in the open. All three species had satisfactory initial stocking from direct seeding. At the end of 2 years, white oak had the least mortality.

The mountain study with northern red oak involved variation in protection from predators, depth of planting, and season of planting. Fifty percent survival at the end of the first growing season was obtained by planting sprouted acorns 1 to 2 inches below the soil surface in the spring.

PROGRESS IN OTHER FIELDS

In addition to the seed research, several major projects were started in 1959. In south Georgia and north Florida, a study of the effect of site preparation upon planted slash pine survival and growth was undertaken with the cooperation of the Georgia Forestry Research Council, the Georgia Forestry Commission, St. Regis Paper Company, Owens-Illinois Glass Company, Rayonier, Inc., Union Bag-Camp Paper Corporation, and Brunswick Pulp and Paper Company. A cooperative study in south Florida involving the American Agricultural Chemical Company and the Babcock Florida Company is measuring response of native range vegetation and slash pine to different levels of rock phosphate fertilization. Direct seeding studies have been installed at Cordele, Georgia.

Two important research summaries were issued during the year. U. S. Department of Agriculture Production Report 30, "Sand Pine Regeneration on the Ocala National Forest," by Robert W. Cooper, Clifford S. Schopmeyer, and William H. Davis McGregor, answers problems associated with natural and artificial regeneration of a species which previously was successfully reproduced only following damaging wildfires. The relationships of soil moisture under forest cover, old-field vegetation, and bare soil in the Piedmont are the subject of U. S. Department of Agriculture Technical Bulletin 1207, by Louis J. Metz and James E. Douglass.

Another important contribution reported a growth study in young slash pine stands. Gruschow and Evans in *Forest Science* showed that in flatwood stands of Florida and Georgia maximum slash pine cubic foot volume growth is realized at less than full stocking, particularly on low sites (fig. 20). The analyses also show that, given time to readjust and occupy growing space, a stand of young slash pine trees will produce about the same volume growth over a fairly wide range of stocking.

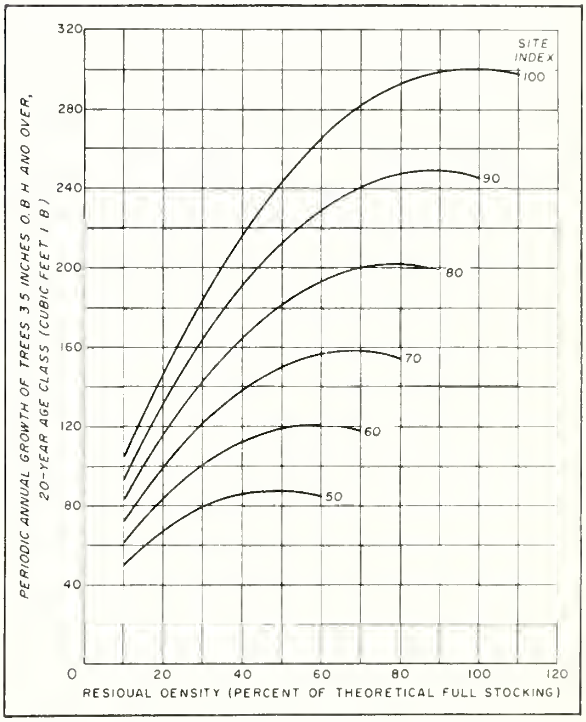


Figure 20.—Relation of periodic annual cubic-foot volume growth per acre to stand density and site quality in 20-year-old slash pine.

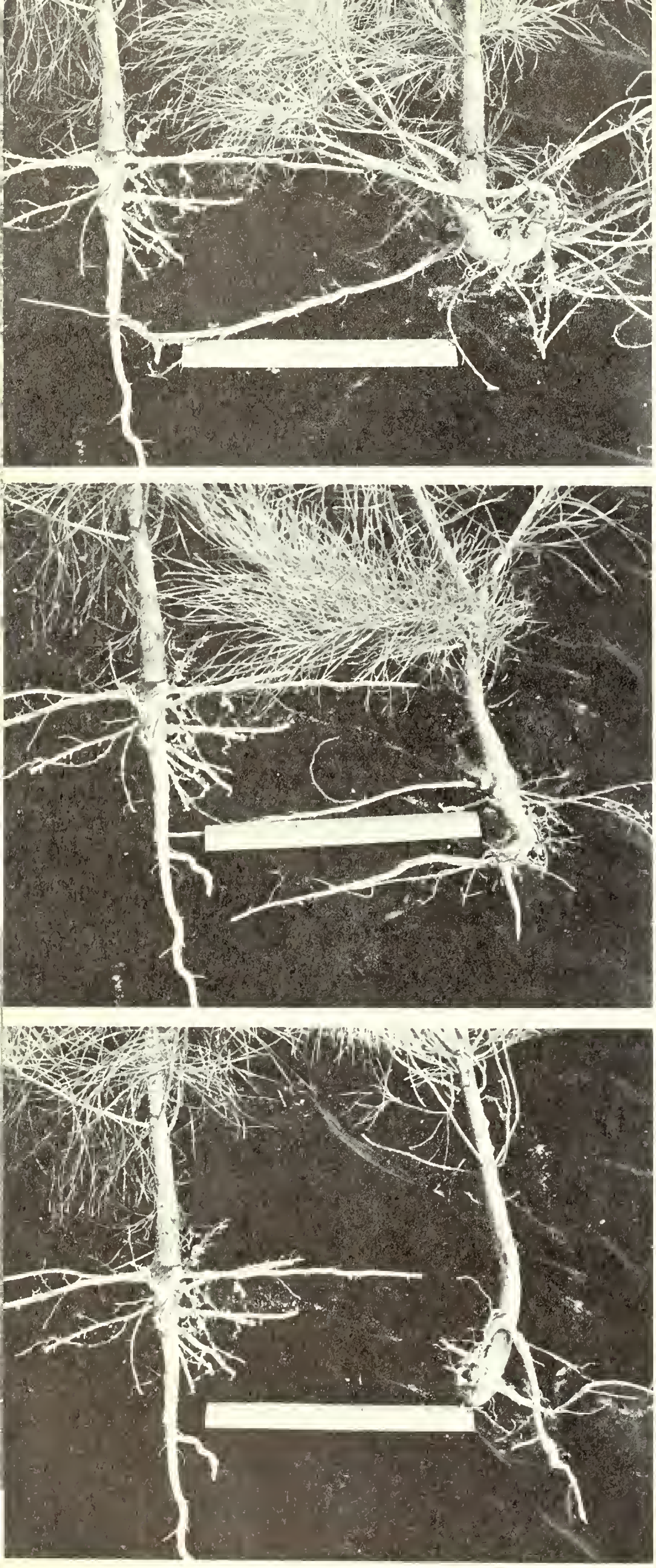


Figure 21.—Typical root systems of natural loblolly pine seedlings (*left*) and bar planted seedlings (*right*).

Artificial Regeneration

Forest plantings of loblolly pine.—A recent study of 3-year-old loblolly pine plantations in southeastern Virginia showed that 67 percent of the trees had malformed root systems caused by poor planting. These trees were bar planted on cutover forest land in 1954-55. Some of the taproots were bent upward, some of them were bent horizontally and were developed at right angles to the direction of a normal taproot, and some were so deformed or cramped that they almost defied classification (fig. 21). The effect of these deformities on the growing trees has not been evaluated, but previous experience has shown that deformed root systems are usually vulnerable to many hazards.

It was also found that forest planters did not make good use of seedling stock in many cases. Effectiveness was seriously reduced by four factors. Alone or in combination, seedling mortality, irregular spacing, overtopping by competition, and unplanned for natural loblolly pine seedlings reduced utilization of the planting stock. The average loss or ineffective use of planting stock is shown in the following tabulation:

	Per acre
Planted seedlings (estimated)	900
Survival at 3 years	579
Less seedlings clustered	68
Surviving seedlings well-spaced	511
Less well-spaced seedlings overtopped	91
Surviving well-spaced, free-to-grow seedlings	420
Less well-spaced, free-to-grow planted seedlings duplicated by free-to-grow natural pine	180
Effective planted seedlings	240

This tabulation points out the futility of evaluating success of forest plantations solely on the number of surviving planted seedlings. On these plantations the resulting natural pine regeneration often made planting unnecessary, and hardwood brush and surviving trees overtopped planted seedlings.

Silvics

Flooding kills yellow-poplar.—Late in 1955 an abandoned field in the overflow bottoms along the Oconee River in Greene County, Georgia, was planted to yellow-poplar. A number of times in the 4 years since establishment the plantations have been covered by highwater during the dormant season and were not damaged. In late May 1959 heavy rains caused an overflow that flooded the plantations for 4 days (fig. 22). One hundred percent kill of tops occurred in some plantings, with mortality as high as 95 percent (fig. 23).

The field results confirmed a controlled study of season and duration of flooding of seedlings planted in small tanks. Seedlings withstood floodings during the growing season for 3 days with little mortality or loss of growth, but extending the period increased mortality until all were dead after 14 days.

Yellow-poplar fertilization.—Three rates of diammonium phosphate (20-52-0) were broadcast over yellow-poplar plantations shortly after outplanting on a soil low by agricultural standards in nitrogen, phosphorus, and potassium. Height growth on the fertilized plots was greater than on the check plot during both of the first 2 years following application (fig. 24). The results of the second-year measurements showed that the effect of fertilization was not falling off, but rather that the gap between the treated and control plots had widened (fig. 25).

Figure 22.—Yellow-poplar planting flooded to a depth of 3 feet in May 1959.

There also were marked differences in foliage color. During the growing season the experiment resembled a checkerboard: rank, dark green foliage on fertilized plots contrasting with sparse, pale green growth on the controls.

Figure 23.—The top of this yellow-poplar was killed, but the sprouts from the root collar indicate that the root system is still alive.

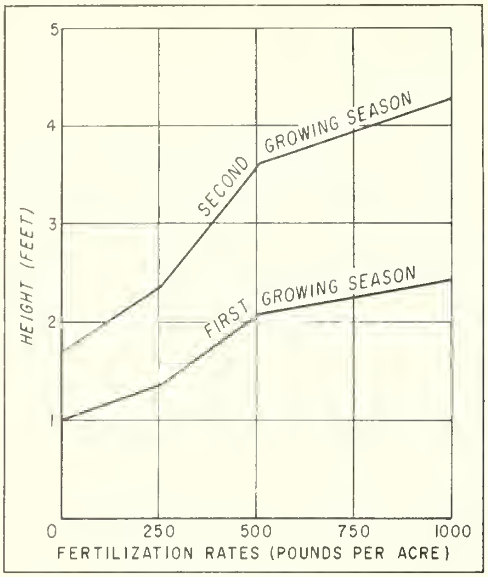


Figure 24. — Average height of yellow-poplar seedlings at the end of the first and second growing season with varying applications of diammonium phosphate fertilizer.

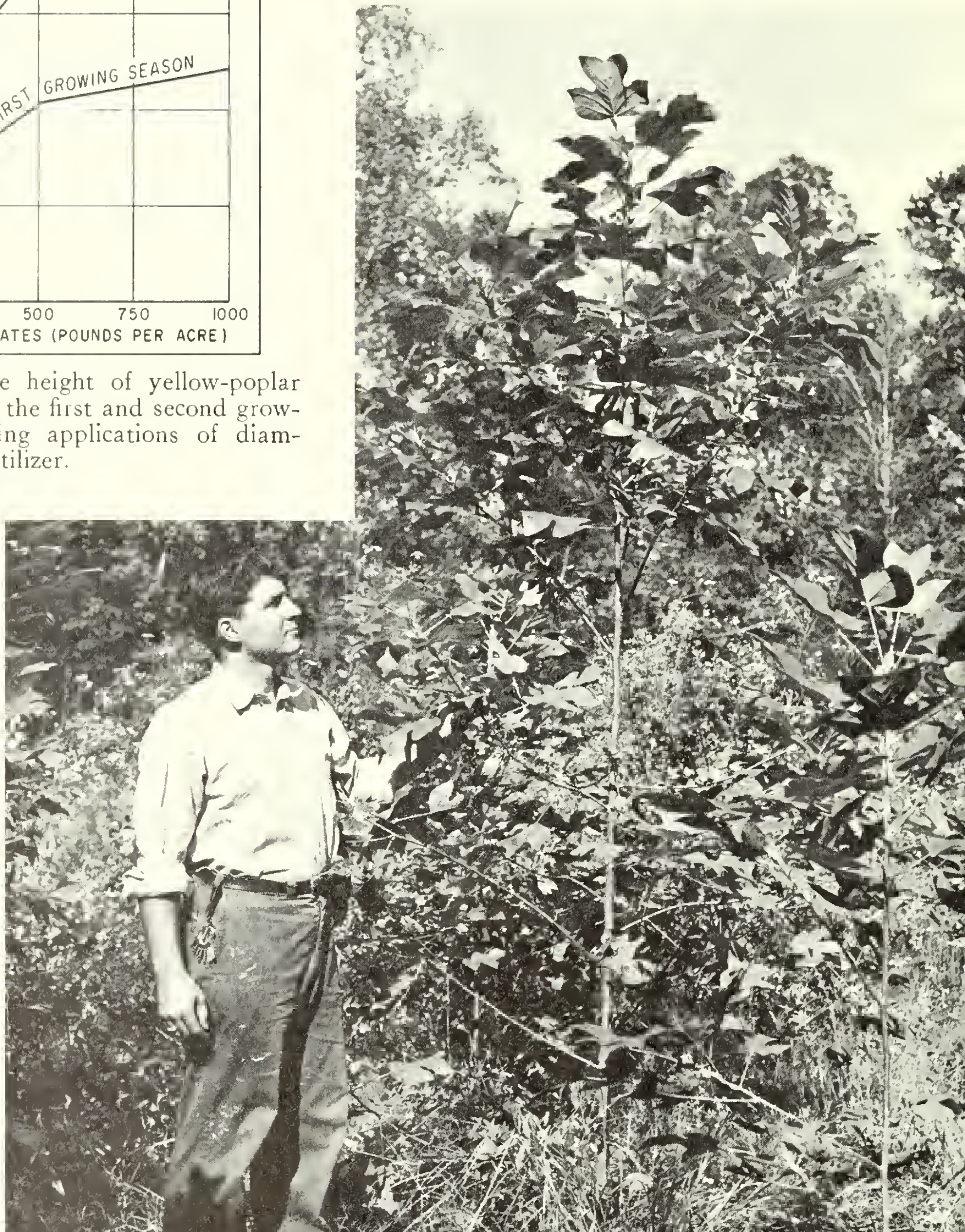


Figure 25.—Many trees grew over 7 feet in height in 2 years following application of diammonium phosphate fertilization at the rate of 1,000 pounds per acre.

Financial Aspects

Grade yields of second-growth yellow-poplar.—Four studies of second-growth yellow-poplar conducted in western North Carolina showed that hardwood log and tree grades can be satisfactorily applied to standing trees.

These studies indicated that site affects the quality of upper grade second-growth yellow-poplar. For example, a 20-inch, grade A two-log tree from site index 120, an excellent site, proved to be worth $52.50 per M stumpage while one from site index 80, a fair site, is worth $40.00 per M stumpage.

Stumpage values for second-growth yellow-poplar rank favorably with other commercial species in the area and show a rapid increase in value with increasing diameters (table 5).

Table 5.—Stumpage values [1] per M board feet by size for tree grades A and B on good sites (site index 100) (Dollars per M board feet)

D. b. h. (inches)	2-log trees	
	Grade A	Grade B
16	37.50	20.00
18	42.50	27.00
20	46.00	31.50
22	49.00	36.00
24	50.50	39.00
26	50.00	40.50

1/ Values based on No. 1 common lumber at $115 per M board feet, less 12 percent for profit and risk, less logging and milling costs.

Naval Stores

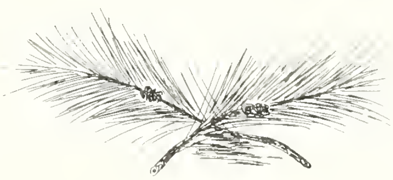
A new yield table for first-year gum yields shows expected yields for ¾-inch, acid-treated streaks on slash pine (table 6). It shows expected yields from trees with faces equal in width to one-third of the tree circumference and ¾-inch bark-chipped streaks sprayed with 50-percent sulfuric acid. The yields are from faces worked biweekly by well-trained labor using the best chipping and spraying techniques.

A test of gum production in south-central Florida showed that South Florida slash and longleaf pine can produce a volume of gum equivalent to that obtained from comparable timber in other sections of the naval stores belt. The application of streaks before the middle of March did not appear to be profitable, but chipping and treating through October for both species were justified and economically feasible. Analyses of oleoresin showed that rosin and turpentine content were within the percentage range expected and the physical and chemical characteristics of the rosin were commercially satisfactory.

Table 6.—First-year gum yields [1] from single-faced slash pines for six diameter classes and five crown ratio classes

D. b. h. (inches)	Gum yields by crown ratios of--				
	0.20	0.30	0.40	0.50	0.60
			Barrels		
9.0	172	190	208	226	244
10.0	209	227	245	263	281
11.0	246	264	282	300	318
12.0	283	301	319	337	355
13.0	320	338	356	374	392
14.0	357	375	393	411	429
15.0	394	412	430	448	466

1/ In barrels (435 pounds) of gum per crop of 10,000 faces obtained from 16 biweekly streaks; no advance streak applied.



FOREST DISEASES

In many ways 1959 has been a year of accomplishment in forest disease research. Major nurseries of the Southeast now fumigate their soil, and are being rewarded by increased production and better quality seedlings. Effective experimental control of cone rust has been achieved, and prospects are good for practical control for seed orchards.

Figure 26.—Blowdown of planted slash pine by Hurricane Gracie in South Carolina. (*A*), Several trees overturned because their roots were rotted by *Fomes annosus*. (*B*), This tree's taproot and several laterals were badly rotted.

A series of oak wilt control appraisal plots are being accumulated that, within a few years, should go a long way toward telling us what we are accomplishing in the state-operated control programs. Important new information has been gained on the localized spread of oak wilt and *Fomes annosus*. Means of identifying several different kinds of white pine needle blights have been developed, although the causes of some remain in doubt.

On the basic research side, techniques for studying the role of mycorrhizae in southern pine nutrition have been developed and, through the use of aseptic cultures of pine seedlings, a mycorrhizal relationship has been proved for several fungi. Pine tissue cultures are being grown in connection with rust studies, and a means of separating organisms in mixed cultures, such as soil dilutions, by electrically induced pH gradients within a single solid-media plate has been demonstrated. The pathology staff authored 16 publications in 1959, and improved its facilities and equipment at the 5 locations where disease research is conducted.

During the past year, *Fomes annosus* became particularly conspicuous as a killer of slash and white pine in thinned plantations. Much windthrow from Hurricane Gracie was due to annosus root decay (fig. 26). The brown spot fungus heavily defoliated white pine in parts of North Carolina and Virginia. The pitch canker, so prevalent a few years ago on many pines, was relatively inactive except on shortleaf pine in one North Carolina county where it teams with an insect and causes material damage. The fungus *Dothiorella quercina* and the pit-making oak scale acting together caused considerable branch dieback in chestnut and white oaks in western Virginia during the past summer. The chestnut blight fungus continues to cause much cankering and killing of post oak in Tennessee. Also noteworthy, but not unusual, were many reports of dogwood leaf blights, Hypoderma needle blight on pine, littleleaf, white pine blight, and mimosa wilt. Each year better surveillance, better surveying, and better reporting give us more reliable estimates of disease occurrence, loss, and the effectiveness of control operations.

Nursery Diseases

Continued research has provided additional information on the serious black root rot problem in Southeastern nurseries, which is caused by species of Fusarium and Sclerotium. Seventeen tree species were grown in soil infested with the root rot fungi to determine their resistance to this disease. Disease reaction of 17 tree species to black root rot is as follows:

Highly susceptible (Species)	*Slightly susceptible* (Species)	*Immune* (Species)
Slash	Spruce pine	Arizona cypress
Loblolly	Redcedar	Baldcypress
Shortleaf		Eastern white-cedar
Longleaf		Sweetgum
Corsican		
Loblolly x shortleaf hybrid		
Sand		
Pond		
Virginia		
Maritime		
Aleppo		

Nemagon, a nematocide which can be safely applied around living plants, was tested against *Tylenchorhynchus claytoni.* Dosages of as little as one-half gallon per acre reduced the nematode population, but the population built up again within a few weeks. Dosages of more than five gallons per acre were necessary to bring and hold the population below damaging levels.

Preliminary investigations have been carried out on the summer chlorosis of nursery stock. The addition of an iron chelate containing 12 percent metallic iron, at 45 pounds per acre, has corrected chlorosis experimentally. Another interesting lead into the possible causes of chlorosis was provided by tissue analysis. Chlorotic needles were higher in calcium than healthy needles. Further work on summer chlorosis is under way.

A disease of eastern redcedar caused by *Exosporium glomerulosum* has been responsible for heavy losses in several plantations in the eastern part of North Carolina. This disease, not previously reported from this area, has also been found in Virginia and South Carolina. Severe infection has been noted in some young plantations, with 10 to 15 percent mortality common. Heavily infected trees are unfit for sale as Christmas trees. Infection usually begins on the lower branches and progresses upward and outward. In severely infected trees, only the needles at the tips of the branches remain alive (fig. 27).

Figure 27.—(*A*), Healthy redcedar in a North Carolina plantation. (*B*), Redcedar severely attacked by Exosporium blight.

Another distinguishing characteristic of the disease is the large number of juvenile needles (fig. 28). The fruiting bodies of the causal organism appear as black dots on the upper surface of the infected needles.

There are indications that Exosporium blight can be controlled with biweekly applications of Phaltan at 2 pounds per 100 gallons of water. Close proximity of several diseased and healthy trees in plantations may indicate resistance to the disease by some individuals.

Phomopsis blight was also severe on 2-year-old redcedars in plantations this year. In contrast to Exosporium blight, this disease causes the death of needles at the ends of branches. Two plantations were complete losses, and heavy mortality was reported in several others. Losses from Phomopsis blight, coupled with injury from *Exosporium glomerulosum*, may make the production of redcedar Christmas trees difficult in the Middle Atlantic States.

Figure 28.—*Left,* Healthy redcedar shoots. *Right,* Shoot with Exosporium blight. Note juvenile needles.

Cone Rust

Significant advances have been made during the past year on the cone rust of slash and longleaf pines caused by *Cronartium strobilinum.* A survey of the cone rust situation in the commercial slash pine area of Georgia and Florida revealed that the heaviest damage was in north central Florida. An abrupt drop in the incidence of cone rust in south Georgia coincided very closely with the northern limits of live oak, one of the most important alternate hosts of this fungus. This correlation indicates that live oaks in the vicinity of seed orchards and seed-production areas may be the most important source of inoculum, but other evergreen oaks are also important. Slash pine seed orchards might best be established north of the live oak range wherever possible.

Direct control measures will often be advisable within the area of high cone rust hazard. Ferbam, at a concentration of 2 pounds per 100 gallons of water, with a spreader-sticker, gave good protection against the disease (fig. 29). Conelets were susceptible to infection during the developmental stages from late twig bud until just after the period of pollen receptivity. To obtain satisfactory protection for the conelets during this period, the fungicide must be applied either before or immediately after each 18-hour or longer period of high relative humidity (over 85 percent) or rainfall.

Ferbam not only controlled the rust, but also stimulated pollen germination. Actidione, at concentrations of 1, 5, and 25 ppm., was toxic to strobili, particularly during the stages immediately preceding pollination, and had little effect on the rust.

Blister Rust Control

Over 6.5 million white pine seedlings were distributed from North Carolina nurseries during 1959, and most of these seedlings were used for plantings in the mountainous section of the State. Because many of these plantations are above 3,000 feet in elevation, and because ribes plants are found primarily at these higher elevations, the blister rust problem may increase. One-fourth of all private plantings have been made within high-hazard zones near ribes, and last year 13 new locations of blister rust were found on native and planted white pine in western North Carolina.

Care must be exercised in locating plantations away from ribes, or in areas where nearby ribes have been eradicated. Only in this way will the control forces of the States and Forest Service be able to hold blister rust losses to a continuing satisfactory low level.

White Pine Blight

This disease, or disease complex, can occur wherever eastern white pine is grown. Symptoms vary considerably and may involve tipburn, needle shortening, chlorosis of needles, reduced shoot growth, premature death, or any combination of these symptoms.

Two and one-half years' data are now available from 14 study plots, each containing 40 dominant or codominant trees, established in 1957. Four of the plots were in the Kingston, Tennessee, area and the remainder were located in Tennessee, Virginia, and West Virginia. There has been higher mortality in the four Kingston plots than in the other plots. The average mortality in these four plots has been 3.7 percent since plot establishment, while only one tree has died of blight on all plots outside this area.

Figure 29.—Spraying for cone rust control, Lake City, Florida, winter 1958-59.

On plots located outside the Kingston area, needle tipburn has occurred only during late spring and summer while the needles are still immature. In the Kingston area, some tipburn occurs at this time but some also occurs during the period from July through the following March. This indicates that there may be two diseases in the Kingston area. One seems to be similar to the emergence needle blight which occurs wherever white pine grows, and the other could be termed a post-emergence needle blight. These two conditions are distinct from the known fungus needle diseases of white pine.

Root systems of white pine suffering from needle-blight have been compared with root systems of trees from healthy areas. There were more dead tips and dead laterals on roots of blighted trees than on roots of healthy trees. In eastern Tennessee, many of the main roots on blighted trees are partially or completely dead. Approximately 1,300 isolations were made from healthy and diseased white pine roots. Twenty-seven genera of fungi have been identified, but in no case was any one organism consistently associated only with the blighted trees, and none of the fungi isolated was a known root pathogen.

A grafting study has been started using the following scion-stock combinations: healthy on diseased, diseased on healthy, and diseased on diseased. Grafted scions, either with or without needle blight, tend to remain in their original condition regardless of the condition of the stock to which they are grafted. This indicates that an above-ground factor is involved in needle blight, and also further substantiates the strong indications that individual trees differ in their resistance to the white pine blight complex.

Mycorrhizae of Southern Pines

The study of the mycorrhizal relationship between four species of southern pines and various mushroom fungi is being continued. Pine seedlings are grown under aseptic conditions in combination with suspected mycorrhizal fungi (fig. 30). Table 7 gives the results obtained with 17 of these fungi on the four species of pine. In this table a dash indicates that an association was tested but not confirmed. Questionable means mantle formation on bifurcate root tips, but no evidence yet of hyphal penetration and Hartig net formation.

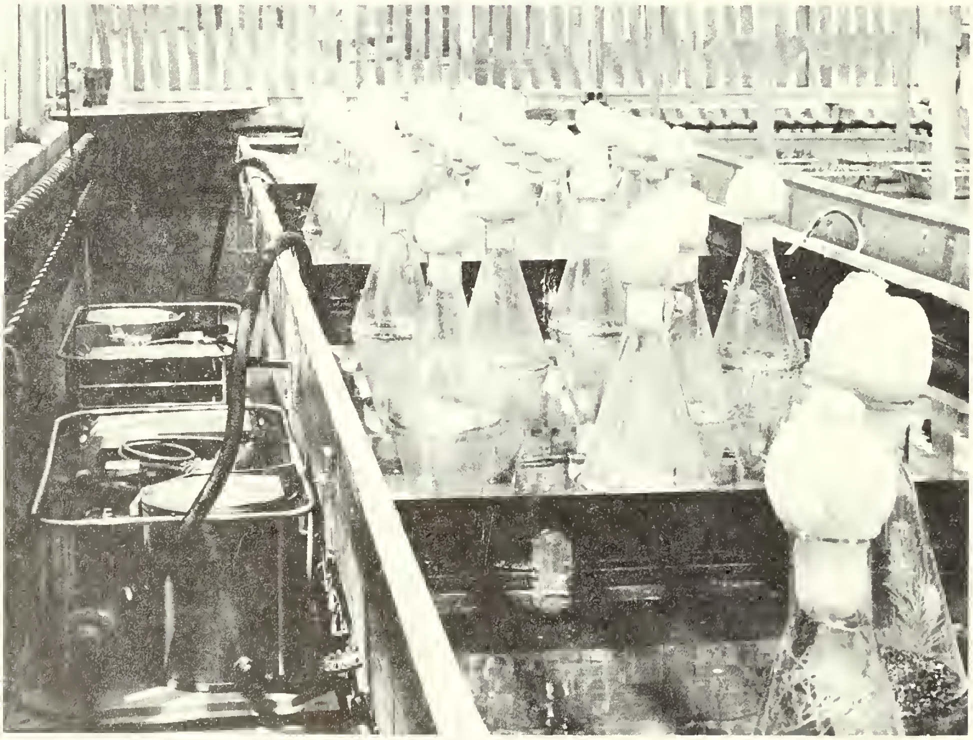


Figure 30.—Thermostatically controlled equipment, at left, cools and recirculates water around flasks in which pine seedlings and suspected mycorrhizal fungi are being tested under aseptic conditions of growth.

Table 7.—Fungi that produce mycorrhizae with pine

Fungi tested	Pine species tested			
	Shortleaf	Loblolly	Slash	Longleaf
Amanita muscaria	--	Positive	--	--
Armillaria mellea	--	Negative	--	--
Boletus betula	Negative	Negative	Positive	Negative
Boletus communis	--	Positive	Positive	Negative
Boletus rubropunctus	Negative	Negative	Negative	--
Boletus sp.	--	Positive	Positive	Positive
Clitocybe laccata	Positive	Positive	Positive	Positive
Clitocybe piceina	Positive	--	--	--
Clitocybe tabescens	Negative	Negative	Negative	Negative
Cortinarius albidipes	--	Negative	Negative	--
Hypholoma sp.	Negative	Negative	--	--
Lepiota procera	Negative	Questionable	Negative	Negative
Lycoperdon sp.	--	Negative	Negative	Negative
Pisolithus tinctorius	Positive	Negative	Negative	Questionable
Psalliota campestris	--	Negative	Negative	--
Lactarius sp.	Positive	Negative	Negative	--
Unknown agaric	Negative	Negative	Negative	Negative

Tests of agar enrichments are being made for the purpose of increasing the number of mushroom fungi that can be isolated in culture. Different culture media are also being tested in an effort to induce sporophore formation in culture. Increased rate of growth has been shown by some fungi grown on humus extract agars, but no species grow on them that will not grow on ordinary malt agar. No fruiting has been obtained except in one test flask culture of *Boletus communis* and slash pine.

Last spring a test was begun to determine the effect of mycorrhizae produced by six different mycorrhiza-forming fungi on the nutrition of various southern pines. Three months after the test was under way sporophores of *Thelephora terrestris* emerged in all tanks, possibly indicating incomplete soil sterilization. Prior to this time, roots of seedlings in the uninoculated control tank were free of mycorrhizae, but now well-developed mycorrhizae were present on roots of the pines. This indicated that *T. terrestris*, common in pine stands of the Piedmont and coastal plain regions, is an important mycorrhiza-former. Despite this contamination, differences in seedling growth were apparent between the various combinations of fungi and pines. Results from this test are not yet complete.

An electrochemical method of producing a fixed, wide-range pH gradient, from about 2 to 10, in agar media has been developed. The gradient is achieved by passage of a weak direct electric current (0.05 ma.) through the agar substrate for periods up to 72 hours. Possible uses include pH studies of microorganisms and tissue cultures of plants and animals, and separation of fungi and bacteria from mixed cultures, such as soil and diseased tissue (fig. 31).

Figure 31.—A direct current is passed through agar for 41 hours. Forest soil is then sprinkled along the electrode path. This photo was made two days after inoculation. The top electrode is positive (pH 2); the bottom electrode, negative (pH 9).

Fomes Annosus Root Rot

Fomes annosus in thinned plantations of white and slash pine has caused increasing concern in recent years. With the large number of plantations now reaching thinning age, this disease may well develop into one of our more important problems.

Research on the means of spread of *F. annosus* revealed that both grafts and mere contact between diseased and healthy roots can transmit the disease (table 8). In another study, typical infections resulted within 12 to 16 months after inoculated root sections were placed against large uninjured roots of 12-year-old white pines. These results agreed with earlier findings that once *F. annosus* became established by infecting fresh stumps it was capable of spreading via roots into nearby healthy trees.

Exposures of agar plates within one badly root-rotted stand where *F. annosus* fruiting bodies were prevalent showed that viable spores were present in the air during every month of 1959. There were fewer spores during the summer than during other seasons. Some of the individual fruiting bodies examined produced spores throughout the year, while others were irregular in spore production.

Oak Wilt

In 1958 and 1959, 42 currently wilting oaks in western North Carolina were sampled by culturing all lateral roots of each tree about 1 foot from the stem. Each tree was within 30 feet of a wilt-killed oak. Forty-six roots of 23 trees contained the wilt fungus near the stem. Root grafts probably served as pathways of infection in only 1 of the 23 oaks examined, although these trees were within the root zones of previously wilt-killed trees. The presence of the wilt fungus in many nongrafted roots at appreciable distances from the stem could be explained only by either the movement of the fungus into the roots from the stem, or the fungus moving directly into the roots by some means other than through grafts. In the case of the 19 infected trees from which the fungus could not be isolated from any of the roots, the implication would be that either some infected roots were missed or that infection did not take place through the root system at all.

The intensive surveys for wilt in two counties in eastern Tennessee continue to yield information on the efficiency of the "felling and spraying" control method. Data collected during the years 1954, 1958, and 1959, when both Greene (control) and Washington (no control) Counties had 100-percent survey coverage, make possible a comparison between treated and untreated areas. In 1954, the year before treatment began in Greene County, there was slightly over 1 new infection center per 100 square miles in each county. The average for 1958 and 1959 is 4.3 in Greene and 9.2 in Washington County. Thus, even though the disease continues to spread (fig. 32), it is encouraging that the rate of spread in the treated area is less than half that in the untreated county.

The East-wide program of post-control appraisal is now in its second year. Critical evaluation of these plots should furnish valuable information on the effectiveness of the various control measures now being used. Forty treated and 29 untreated plots have been established in the southern Appalachians. A meaningful comparison of these plots is not yet possible, since only one year's results are now available.

Table 8.—Root grafts and root contacts as avenues for *Fomes annosus* spread between white pines

Stand description	Infected trees examined	Infected roots examined: Total	Infected roots examined: Root transmission through-- Graft	Infected roots examined: Root transmission through-- Contact
	- - - - -	- - - - Number	- - - -	- - - - -
Natural, 35-65 years old	6	18	5	5
Planted, 31 years old	11	44	14	7

Figure 32.—A large group of oaks killed by wilt in east Tennessee.

Littleleaf

In 1953, twelve lots of shortleaf pine seedlings grown from seed collected from different geographic sources within the natural range of this species were planted in South Carolina, Virginia, and Georgia, on severe littleleaf sites. The trees are being observed for possible resistance to littleleaf. Height data recorded after the sixth growing season in the field revealed no great differences between sources because of much variation within sources. Best growth, however, is represented by the Nevada County, Arkansas, source and poorest growth by sources from Pennsylvania and Texas.

In 1940-41, twenty-seven plots, distributed from Virginia to Alabama, were established to study the onset and development of littleleaf over a period of years. Nine plots were in severely diseased stands, 9 in moderately diseased stands, and 9 in healthy stands. Sixteen years later the losses from littleleaf were very high (table 9), showing that much of littleleaf belt will have to be operated on a short rotation for shortleaf pine.

Table 9.—Decline from littleleaf after 16 years in 27 plots of shortleaf pine

Plot condition in 1941	Trees diseased in 1941	Trees dead in 1957	Trees dead or diseased in 1957
	- - - - Percent - - - -		
Healthy	1	25	49
Moderately diseased	12	29	75
Severely diseased	33	62	86

FOREST ECONOMICS

Field work on the third Forest Survey of Florida was completed in 1959, and Georgia's third Survey was begun on August 1. By December 31, plot data had been collected in 17 of the State's 159 counties (fig. 33). Remeasurement of sample plots established during the 1950-53 Georgia inventory is expected to increase the accuracy of estimates of timber cut and tree mortality.

An innovation on the Georgia survey is the use of "area condition classes" for evaluating present and potential forest productivity. A systematic arrangement of point-samples at each Survey plot provides this classification and indicates the type of silvicultural treatment, if any, that is needed.

Electronic data processing machines are being evaluated for speeding Forest Survey computations. A test was made to compare relative efficiencies of two electronic computers for processing Florida Forest Survey statistics. Three members of the Division attended a Forest Service conference in Atlanta to discuss new opportunities for adapting automatic computers to the solution of forest inventory and management problems.

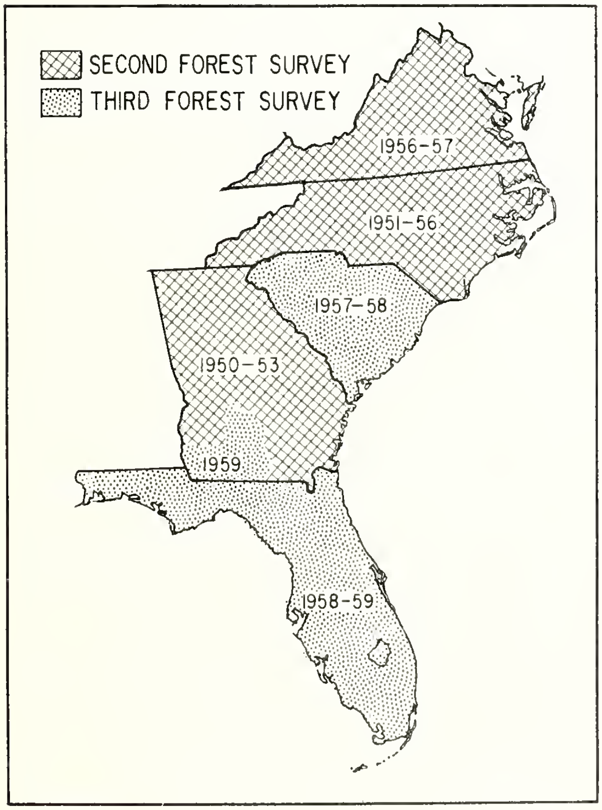


Figure 33.—Status of forest survey field work in the Southeastern States.

A national Forest Survey-Timber Management meeting was held in San Francisco in November. Divisional representatives presented technical papers on "Improving Accuracy of Volume Tables," "Long-term Growth and Volume Projections," and "Procedures for Integrating Field and Photo Estimates of Area and Volume."

A 100-percent production canvass was made of Florida wood-using industries, along with a study of fuelwood and fence-post production. Results will be published in a report during 1960. Also completed in the past year were the annual surveys of southern pulpwood production and prices, conducted in cooperation with the Southern Forest Experiment Station and the Southern Pulpwood Conservation Association. The production data were published as Forest Survey Release 82 of the Southern Station. Another cooperative project with the Southern Station involved the preparation of tree species distribution maps for 11 important conifers of the South. These maps are to be published early in 1960.

A new study in the economics of forest management and cultural treatments (thinning, girdling, site preparation) was started with the cooperation of Duke University. The first phase of the project, a library search for input-output data, was conducted by a graduate student as a thesis problem. As a follow-up, Duke Professor James G. Yoho visited southeastern forest industries, state forestry departments, and schools of forestry in search of unpublished input-output data.

As one result of an industrial development study in the North Carolina Piedmont, the State Extension Service and the Southeastern Station are publishing a series of timber marketing guides for each of 8 counties in the study area. These guides include names and addresses of wood purchasers by type of product, the specifications under which they buy, and other information of value to prospective sellers.

The Asheville staff was saddened by the untimely death in February of James F. McCormack, Chief of the Division of Forest Economics Research. Jim had been with the Forest Service for 24 years and had worked for the Southeastern Station since 1945. A. S. Todd, Jr., is now Acting Chief of the Division. A new addition to the Forest Survey staff is Dr. Gene Avery, who transferred from Washington, D. C., in July. Avery is in charge of Survey computations and will carry out special studies in forest aerial photogrammetry. Two men, Don Steensen and Joe McClure, are now taking graduate studies at Duke University.


C


A


D


B

THE FOREST SURVEY IN BRIEF

A. Permanent plot locations are transferred from aerial photographs used on the previous Survey to current prints by proportional dividers. Field crews use the new photos to locate the exact sample point on the ground.

B. A special graduated steel tape is used to define the limits of the variable-radius sample plot upon which tree tallies are taken. Field data are entered on plot sheets by numerical codes.

C. After field plot sheets have been double-checked for errors, coded entries are punched into IBM cards to facilitate faster compilations.

D. When all punched cards have been verified and sorted according to plan, tabulations of tree and plot data are made on an IBM accounting machine. The final statistics to be shown in published Survey reports are developed from these tabulations.

Many Opportunities to Increase Productivity of Forest Land in South Carolina

On over half of the commercial forest land in South Carolina much of the timber growing capacity is being wasted. Only 29 percent of this forest area is well stocked with pine (table 10). This commercial forest land includes 3.2 million acres of lowland hardwood types. Forest industries must depend on these lands for the main supply of high quality hardwoods, and yet only half of this area is well stocked with hardwoods of high enough quality to make saw logs, now or prospectively. Even in these better stocked stands productivity could be further increased by thinning overly dense pine stands and by improving the quality and species composition of the hardwood stands.

Stands on 2.8 million acres of commercial forest land are medium to well stocked with pine or hardwood growing stock, but the outlook for further improvement in stocking is very poor because of the presence of such material as shrubs, culls, and low quality hardwoods. Stand improvement measures are needed on these areas.

Table 10.—Commercial forest area by major type of action needed to increase productivity, South Carolina, 1958

Type of action needed	Commercial forest area	
	Thousand acres	Percent
No action needed:		
Well stocked with pine	3,443.9	28.8
Well stocked with hardwoods	1,679.2	14.1
Total	5,123.1	42.9
Stand improvement:		
Pine stands	1,293.1	10.9
Hardwood stands	1,518.3	12.7
Total	2,811.4	23.6
Regeneration:		
Without site preparation	458.8	3.8
With site preparation	3,541.6	29.7
Total	4,000.4	33.5
Total	11,934.9	100.0

A third or remainder of the commercial forest area shows very little promise of becoming well stocked with desirable timber in the near future. For the most part, this area does not have enough desirable timber on it to justify trying to improve the present stand; it needs regeneration. Included in this total are upland sites which are less than 40 percent stocked with pine. On about one half million acres less than 20 percent of the area is covered with unwanted vegetation and this area could be planted without site preparation. But most of this area with little or no prospective growth will require the removal of unwanted trees and shrubs before the area can be planted.

While most of this upland forest area is suited to growing pine, how much should be devoted to this purpose depends on the comparative need for pine and hardwoods. A small area of mountain sites and the most productive piedmont sites are probably better suited to growing hardwoods than pine. Also, other sites may be best utilized by growing a mixture of pine and hardwoods. For the most part the prospective need for hardwoods can best be met by increasing the productivity of the lowland sites which are not suited to growing pine.

In addition to this 4-million-acre backlog of forest land that could be planted to pine, if this seemed desirable in the light of prospective industry needs, there are 1.4 million acres of idle cropland, much of which, if past trends continue, will be available for timber production.

The bulk of the forest land which would profit from treatment is owned by farmers (table 11). This reflects mainly the large area in farm ownership in the State, but it also reflects the poorer condition of farm woodlands. Sixty-two percent of the farm woodlands are in need of treatment, compared to 46 percent of the publicly owned forest land and 48 percent of the forest land owned by forest industries.

Timber Cut and Mortality Estimates in Georgia

With the start of the third Forest Survey of Georgia in August 1959, remeasurement of permanent sample plots became the basis

Table 11.—Commercial forest area needing treatment by type of ownership, South Carolina, 1958

Ownership	Total	Needing treatment	
	Thousand acres	Thousand acres	Per-cent
Public:	1,034.4	476.8	46
Private:			
Forest industry	1,672.5	796.7	48
Farm	6,827.2	4,204.7	62
Miscellaneous private	2,400.8	1,333.6	56
Total	10,900.5	6,335.0	58
Total	11,934.9	6,811.8	57

for estimating average annual volume of timber cut and mortality. All trees that were 3.0 inches d. b. h. or larger at the time of the 1950-53 Survey were identified. Those cut or dead were tallied by species, size, class of material, and cause of death. Examination of the field records for the first 660 plots remeasured in Georgia showed that 50 percent were disturbed by cutting and 24 percent by mortality during the 9-year period between Surveys.

Plot remeasurement has the following advantages over former methods of estimating timber cut and mortality:

1. Estimates are not affected by the reporting errors that may bias production surveys based on canvasses of timber operators and wood-using industries.
2. Plot remeasurement provides an accurate estimate of changes resulting from cutting and mortality. Previous estimates based on stump and dead-tree counts were suspected of being too low because of missed stumps and over-estimation of the period since cutting or death.
3. Remeasuring plots at 5- to 10-year intervals provides estimates of average annual cut that are not unduly affected by temporary conditions, such as short business booms or recessions, droughts, and damage from a single hurricane. Conversely, the shorter periods required for accurate stump and dead tree counts on newly established plots do not afford this protection.

New Method of Classifying Forest Area

For several years, efforts have been made to develop a method of area classification that adequately and efficiently describes forest stands. Small areas can be accurately classified from actual measurements, such as a complete tally of all trees on a 1/5-acre plot, but classification based on these small areas tends to exaggerate extreme conditions. For example, in terms of areas that landowners would consider planting or harvesting, the area of nonstocked land or large sawtimber stands tends to be overestimated.

Recent technique studies indicate that classification based on conditions over at least an acre will greatly reduce this tendency to exaggerate extreme conditions. Classification of an acre based on complete measurement, however, is too costly, and an ocular classification tends to be highly subjective and involves a high risk of error. A compromise solution to this difficulty, which makes use of a sample of conditions on the acre, is being tried out on the third Survey in Georgia. The procedure measures both area controlled and area distribution of the significant types of forest vegetation on the acre.

The method consists of recording the frequency of occurrence of trees and shrubs on 20 variable-size circular quadrats having a common center. These points are located 30 links apart on a 6-chain square traverse around the center of the acre. Quadrat size is determined by the number of well-spaced trees required to fully utilize the acre, which in turn varies with the size of the tree. In Georgia, the radius of the quadrat (limiting distance) in feet is equal to the d. b. h. of the tree in inches. This permits the use of an angle gage or wedge prism with a basal area factor of 75.625 to determine the occurrence of any size tree at a point. Where two or more trees fall within the limiting distance of the point, occurrence is assigned to the most dominant tree.

A summary of the number of points controlled by various types of vegetation provides the basis for estimating forest type, stand size, and stocking class. It also provides the basis for estimating current and prospective stocking of desirable trees and the type of forestry action required to increase stocking.

Recording recent changes in the tree or shrub cover controlling each point provides a measure of the effect of cutting, forestry practices, and damage from fire, insects, and disease on stocking.

Trial of Electronic Computers for Processing Forest Survey Data

Forest Survey data for northwestern Florida were processed using both the IBM 607 electronic calculator (the present method) and the IBM 650 electronic computer. Results of the comparative test were reported at a Forest Service conference at Atlanta in September.

Cost of the two methods was approximately the same, but each machine had certain merits to commend it. Advantages of the IBM 607 computer are:

1. It is a simpler machine to program and operate than the 650. Thus, the problem of training or hiring competent programmers is considerably less.
2. A Survey processing program based on the 607 computer is more flexible and more easily modified than one based on the 650.
3. Additional computations not originally anticipated can be handled quickly and economically.

Advantages of the IBM 650 computer are:

1. Time required to process the data for a Survey unit might be only one week as compared to at least a month using the 607.
2. Once a 650 program has been thoroughly checked, there is less chance of human error because it requires less card handling and fewer processing steps.
3. The 650 is more reliable than the 607 because of the automatic computational checks built into the machine. Undetected machine errors are virtually non-existent with the 650 but are encountered occasionally in 607 computations.
4. A 650 program can produce information in more usable form than the 607. The greater storage capacity of the 650 permits combining and punching out information in summarized form.
5. The 650 easily handles complex volume equations that cause difficulties when using the 607.

Increased Pulpmill Demand for Hardwoods and Wood Residues

Pulpwood production in the Southeast made a slight recovery during 1958 from the recession low of 1957, but remained 251,000 cords under the record level of 11,272,000 cords set in 1956 (table 12). The partial recovery was due entirely to increased utilization of hardwoods and wood residues, principally sawmill chips. Pine pulpwood production was at its lowest level since 1954, more than a million cords below the 1956 peak. Hardwoods, on the other hand, continue to show an increase each year. The 1958 production of 1,344,000 cords was 248,000 cords above 1956. Wood residues have nearly doubled every year since 1953, and the 1958 production of 732,000 cords was 279 percent above 1956.

The rapid growth of the pulp and paper industry, as measured by the level of pulpwood production, has suffered only one other setback since World War II. The recession of 1949 depressed the markets for both pine and hardwoods but both recovered the following year. In 1956, only pine production declined, and it fell an additional 422,000 cords in 1958.

Pulpwood prices in the Southeast remained stable at record levels. The 1958 survey of pulpwood prices revealed only slight changes from the previous year. Average pine prices remained unchanged at $15.50, in spite of the pronounced drop in production, while hardwood prices averaged $13.45, ten cents a cord higher. Chip prices were steady—$6.10 per ton at most mills.

Which Landowners Practice Forestry?

Why does one person practice forestry while his neighbors do not? The answer to this question is a key to what action would make the region's small woodlands produce more timber for industry and more income for owners. Data from interviews with 200 landowners were analyzed to see if the individuals most interested in forestry display any features that distinguish them from other owners (fig. 34). Of the 200, half believe that forestry is or could be profitable for them, but only a third actually practice it.

Individuals who practice forestry tend to have three characteristics in common. First,

Figure 34.—Interviews with 200 small forest landowners show that only a third of them are practicing forestry.

they have sold timber within the past 10 years. Second, they are the younger landowners. Third, their woodlands rank above average in both actual acreage and proportion of the entire property that is forested.

Among persons who sold timber during the past 10 years, one out of three is practicing forestry. This is in contrast to one out of four of those who did not sell. One reason why owners who recently sold timber may be more inclined to practice forestry is that by selling they realize they can earn income from their woodlands and so are more willing to invest in them. Another possible reason is that some of the people encountered in the course of making a timber sale may stimulate the owner's interest in forestry by showing him how returns from his woodland can be increased by practicing forestry.

Table 12.—Pulpwood production and prices in the Southeast, 1945-1958 [1]

Year	Pine roundwood		Hardwood roundwood		Wood residue	
	M cords	Dollars per cord	M cords	Dollars per cord	M cord equiv.	Dollars per ton
1945	3,806	8.45	525	8.10	--	--
1946	3,993	10.10	718	9.70	--	--
1947	4,171	10.95	665	9.80	--	--
1948	5,565	11.70	768	11.05	--	--
1949	4,942	11.00	594	10.80	--	--
1950	6,140	11.90	717	11.00	--	--
1951	6,916	13.85	826	12.75	--	--
1952	7,030	13.90	744	12.80	--	--
1953	7,990	13.90	806	12.75	28	--
1954	7,964	13.95	852	12.75	54	--
1955	9,076	14.35	1,006	13.05	112	--
1956	9,983	15.45	1,096	13.50	193	--
1957	9,367	15.50	1,190	13.35	427	6.10
1958	8,945	15.50	1,344	13.45	732	6.10

1/ Prices are weighted averages of all wood loaded on railroad cars, trucked to pulpwood yards, and delivered to pulpmills. They include dealers' allowances in cases where they are paid.

People who practice forestry are, on the average, about 20 years younger than those who do not. Young people tend to be more interested in forestry than old people, not only because they have a longer time in which to reap returns from forestry investments, but also because they are more likely to have been influenced by forestry educational programs.

The woodland area of owners who practice forestry is twice as large as that of those who do not, and it makes up a larger proportion of their total property—about 20 percent more. This suggests that an individual's interest in increasing the productivity of his woodland depends upon how important a part it is of his total assets.

The fact that people who practice forestry have common characteristics that distinguish them from those who do not indicates that possibly there are definite factors which motivate owners to practice forestry that can be uncovered. Such knowledge would be highly valuable in planning forestry programs.

FOREST FIRE

FIRE BEHAVIOR

The "Pungo 1959" Fire - - A Case Study

The Pungo 1959 fire burned April 8 to 11 in the low, swampy organic soil area of coastal North Carolina in Hyde and Tyrrell Counties, the scene of many disastrous fires in past years. The fire started on the afternoon of April 8 when a brush disposal burn spotted over a protective canal into a brush fuel that was about 4 feet tall and weighed about 8 tons per acre (fig. 35). The maximum rate of spread was about 1 mile per hour, and the fire ran uncontrolled until late that night when rising humidity stopped the head.

Conditions at 2:00 p.m. on the 8th were: burning index, 60; buildup index, 44; fuel indicator slats, 3.8 percent moisture; air temperature, 80° F.; relative humidity, 50 percent; and wind speed, 10 miles per hour. The ground water table was near the surface, precluding ground burning. Taken together, these measurements indicated very severe burning conditions. As a result, the surface litter, brush foliage, foliage on pond pines 5 to 6 feet high, and stems smaller than 3/16 inch in diameter were generally consumed—an estimated 56 percent of the total fuel.

Winds aloft profiles over stations surrounding the fire area could be considered borderline from the standpoint of extreme fire behavior. The absence of clear-cut adverse wind profiles, the high water table, and rather low fuel volumes, probably explain why the fire did not exhibit extreme behavior.

The next day, April 9, the fire broke out again near its origin and by 1:30 p.m. a very high intensity head had developed (fig. 36) which made a run for the day of about 11 miles and burned perhaps 10,000 acres, most of it between the hours of 1:00 p.m. to 4:00 p.m. The estimated rate of spread was over 2 miles per hour during this period. At its peak intensity, the fire had "blowup" characteristics except for long distance spotting and whirlwinds. These may have occurred but were not reported, possibly because men were not near enough to the fire front to observe them. Spotting up to 400 feet ahead of the fire was observed about 3:00 p.m.

There was extremely strong convective activity over the fire; the smoke column, which had a white water-vapor cap, boiled up to a height of 10,000 feet. Measurements from timelapse camera photos indicated that updraft velocities in the top of the convection column reached 25 miles per hour. Velocities within the center of the column could not be measured but may have been twice as great.

Figure 35.—Gallberry and fetterbush brush type burned on April 8 by the Pungo 1959 fire. Fifty-six percent of the 8 tons per acre of total fuel was consumed. Unburned fuel is in the background.

Figure 36.—Convection column at 2:50 p. m. on April 9 during the blowup period. Fuel weighed 14 tons per acre, and 9½ tons per acre were consumed.

Timelapse photography techniques permitted study of several other fire behavior characteristics not normally discernible. For example, the characteristic outward and downward rolls on the flanks of the growing smoke plume were plainly visible.

During the period of greatest intensity the fire burned in three different fuel types, ranging from a loblolly bay-fetterbush brush type weighing 9½ tons per acre to a very tall cane-tall gallberry type weighing 15 tons per acre (fig. 37). Fuel consumption ranged from 64 to 93 percent of total weight with the heaviest fuels burning most completely (fig. 38). In all types, brush foliage and stems smaller than 3/16 inch in diameter were consumed: cane was consumed completely. Pond pine foliage was consumed to a height of 10 feet and the rest scorched.

The 2:00 p.m. fire danger station readings were: burning index, 65; buildup index, 50; fuel indicator slats, 5 percent moisture; air temperature, about 83° F.; relative humidity, 67 percent; and wind speed, about 20 miles per hour. Winds aloft profiles over Cherry Point and Norfolk, two stations located in or near the air stream passing over the fire area, were conducive to extreme fire behavior (fig. 39).

Progressively smaller runs occurred on April 10 and 11, but by this time fire weather had moderated and effective suppression action brought the fire under control. From a fire behavior research standpoint, the runs of April 8 and 9 are of most interest in that the fires were free burning and unaffected by suppression action.

Figure 37.—Very tall cane-tall gallberry brush type (about 7 feet tall) before the fire contained 15 tons per acre of understory vegetation and litter.

Figure 38.—Very tall cane-tall gallberry brush type after the big run on April 9. About 14 tons of the total 15 tons per acre of fuel were consumed, not counting crowns of the overstory pond pines.

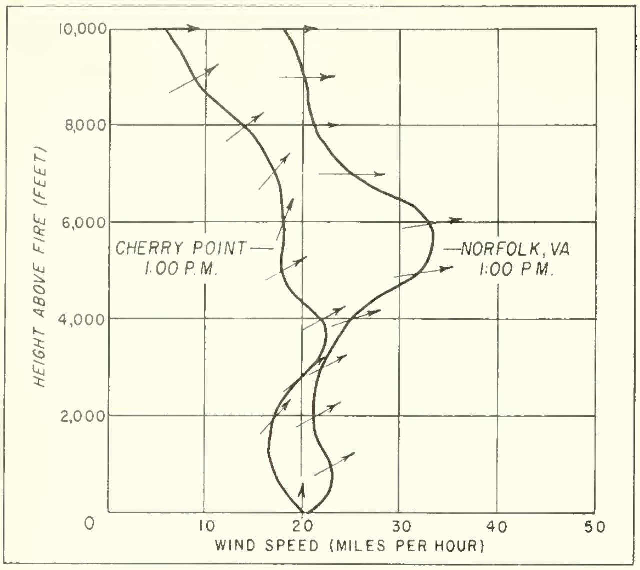


Figure 39.—Wind speed and direction above two stations in the wind stream over the fire area on April 9, 1959. Both profiles were classified adverse, based on the "Key-Vertical Wind Profiles and Associated Fire Behavior in Flat Country." Note that the wind at 10,000 feet is blowing clockwise to the surface wind. The convection column changed direction accordingly.

Ember-Lifting Power of Convection Column Updrafts

Advances in fire behavior knowledge in the last few years have reduced considerably the element of mystery which in the past has been associated with high-intensity fires. The Division's work in fire behavior has been based primarily on an energy approach and much of the effort has been directed toward describing fire behavior in quantitative terms. This work, some of which was described in the Station's annual report for last year, could be designated more briefly as the task of "putting numbers" on fire behavior.

The quantitative description of fire behavior has ranged from relatively simple problems, such as defining fire intensity in terms of rate of energy output, to more complex problems, such as the study of energy conversion processes in the convection column and the development of scaling laws for work in fire modeling.

How the development of a specific quantitative relationship can remove some of the mystery of fire behavior is illustrated by an analysis of one phase of the spotting process: namely, the relationship between fire intensity and the ember-lifting power of the updrafts over a fire. This relationship can be expressed in dimensionless form by the equation $W/W_0 = (I/I_0)^2(D/D_0)^2$ in which W_0 is the weight and D_0 the density of an ember which will just be supported in an updraft over a fire with a reference intensity of I_0. The weight W and density D apply to an ember which will be supported by the updrafts over a fire of any given intensity I. The quantities W_0 and W could also be regarded as the weights of the model and full scale embers respectively.

The equation expresses an important relationship. It shows that the weight of an ember which can be carried aloft by the updrafts over a fire is directly proportional to the square of the fire intensity. For example, a three-fold increase in fire intensity should correspond to nine-fold increase in ember weight which the updrafts can support. This may explain in part why the meeting of a head fire and backfire can sometimes result in extensive spotting. A similar phenomenon can occur when a fire burns into heavy fuel. The equation also shows that the weight of an ember which can be carried aloft is inversely proportional to the square of the ember density. Thus embers of low density, such as decayed wood, or punk, would be carried aloft more readily than embers of denser substance but of equal weight.

The derivation of the equation is based on the assumption that the drag force acting on a falling ember is directly proportional to the square of the speed of the ember relative to the environmental air. This assumption requires that the dimensionless drag coefficient for an ember of any given shape be approximately constant throughout a wide range of Reynolds' numbers. This approximation is very good for a wake-producing object, such as a flat plate with its surface perpendicular to the direction of flow, but is not so good for

a smooth object with a more streamlined shape. However, the approximation may be good for most ember material but this will have to be determined by experimental tests.

Dimensional relationships given by the equation of motion for an object falling in a resisting medium indicate that the drag coefficients for different kinds of embers can be determined by relatively simple free-fall tests from heights which may not have to exceed 100 feet. These tests will also give for different embers the Reynolds' numbers corresponding to their terminal velocities. Depending on the size, shape, and density of the ember, the Reynolds' number in most cases will likely fall somewhere in the range from 2×10^3 to 6×10^5.

One Year's Experience with the Winds Aloft Monitoring System

Based on reports from the North Carolina Division of Forestry, experience with the winds aloft monitoring station at New Bern, North Carolina, has been decidedly favorable.

In the high-hazard organic soil area of coastal North Carolina, soundings of wind speed and direction aloft have been taken since the fall of 1958 during periods when fire danger was progressively increasing. Interpretation of soundings in terms of the potential for extreme fire behavior was made, using the interim report, "Key-Vertical Wind Profiles and Extreme Fire Behavior," prepared by the Division. Expected fire behavior is considered in suppression activities on going fires or used in presuppression planning according to procedures established by the state.

Whenever a profile is adverse, that is, conducive to extreme fire behavior, a special warning is issued by the district dispatcher in New Bern to suppression units in his and other districts and to cooperators. Units with small going fires increase their control efforts in an attempt to keep the fires below the size at which a blowup might occur.

On large fires the warning is used as a basis for adjusting deployment of control forces to make them more effective and as an alert for possible evacuation in case a blowup occurs. When the direction aloft differs from that of the surface winds, air and ground patrols are instructed to be especially watchful for spotting in the direction of the wind at the upper levels. On numerous occasions, suppression forces noted symptoms of unusual fire behavior before control was achieved on days with adverse wind profiles and high fire danger.

During the 16,000-acre Pungo 1959 fire in April, the start of the blowup period and main run were observed to coincide with the onset of an adverse profile. The fire boss reported that the warning provided by upper air soundings was extremely valuable in understanding the behavior of the fire and in planning successful suppression action.

As a result of favorable first-year experience with the system at New Bern, a second station has been established at Whiteville, 100 miles to the south. Data from the two stations will be compared to study the areal extent of a given wind profile.

FOREST FUELS

Classification of Forest Fuels in Terms of Total Fuel Energy

Classification of the principal forest fuel types in the organic soil area of coastal North Carolina in terms of total fuel weight (directly convertible to total fuel energy) was completed in 1959. Three additional types, wiregrass, high pocosin, and very high cane (figures 40, 41, and 42), were added to the eleven sampled previously on Hofmann Forest. Together they represent the range of fuel types and fuel weights to be found in the organic soil areas of North Carolina.

The tentative classification system is summarized below:

Total fuel weight class (Tons/acre)	*Fuel type*	*Total fuel weight* (Tons/acre)
4.1-5.7	Wiregrass	4.46
5.8-8.0	Low Brush Open	5.90
	Low Brush-Cane Open	6.42
	Low Brush-Grass	6.54
8.1-11.0	Low Brush Dense	8.25
	Low Cane	8.80
	High Cane	9.78
	Medium Brush	8.58
	Low Brush (Sand Ridge)	9.18
	Low Brush	8.46
11.1-16.0	High Pocosin	15.00
	Very High Cane	12.83
16.1-23.0	High Brush	17.47
	High Brush (Swamp)	18.86

In the tabulation each succeeding class has significantly greater potential for extreme fire behavior. Using available laboratory facilities, calorimeter tests will be made to determine the heat content of the different fuels. The unit of measurement then will be Btu's rather than tons.

Guidelines for identifying and mapping the fuel types in the field are being developed.

Figure 41.—High pocosin fuel type. Composed of gallberry, redbay, cane, and greenbrier, this type contains 15 tons per acre of understory vegetation and litter. The overstory is pond pine.

Figure 40.—Wiregrass fuel type. The understory vegetation and litter weighs about 4½ tons per acre. The overstory is pond pine.

Figure 42.—Very high cane fuel type. This type contains 13 tons per acre of understory vegetation and litter. The overstory is pond pine.

Moisture Regime of Understory Vegetation in Coastal North Carolina

The moisture content of forest fuels, including the litter and dead and green standing vegetation, exerts a strong influence on fire behavior. In general, fire intensity and rate of spread are inversely proportional to fuel moisture content The moisture content of dead forest fuels is known to fluctuate with the weather but the moisture regime of living vegetation is less well known.

Understory vegetation is a major component of forest fuels on the organic soils in coastal North Carolina. As part of a comprehensive study of fuels in this fire problem area, moisture content determinations of whole plants of gallberry (*Ilex glabra*), redbay (*Persea borbonia*), swamp cyrilla (*Cyrilla racemiflora*), and switch cane (*Arundinaria tecta*) were made for nearly one year in 1959. Figure 43 indicates that moisture content can vary widely by season and among species. The largest differences occurred during the spring and fall. During these seasons, cyrilla had the greatest change, 45 percent. Of the other species, redbay had a range of 35 percent, gallberry 25 percent, and switch cane 20 percent. In the spring the moisture content of all species except gallberry started to increase about April 1, rising fairly rapidly to a maximum about May 15 for cane and July 1 for the other species. The increase for gallberry began six weeks later. A gradual decrease in the moisture content of cane began about June 1 and, for the other species, July 15.

The moisture contents of foliage and stem components followed the same general seasonal regime as the whole plant except that moisture maximums and seasonal changes for foliage of all species were much greater than for whole plants. Cyrilla foliage, for example, varied from 195 percent moisture content in the spring to 120 percent in the witner, a difference of 75 percent. Stems seldom fluctuated more than 20 percent in moisture con-

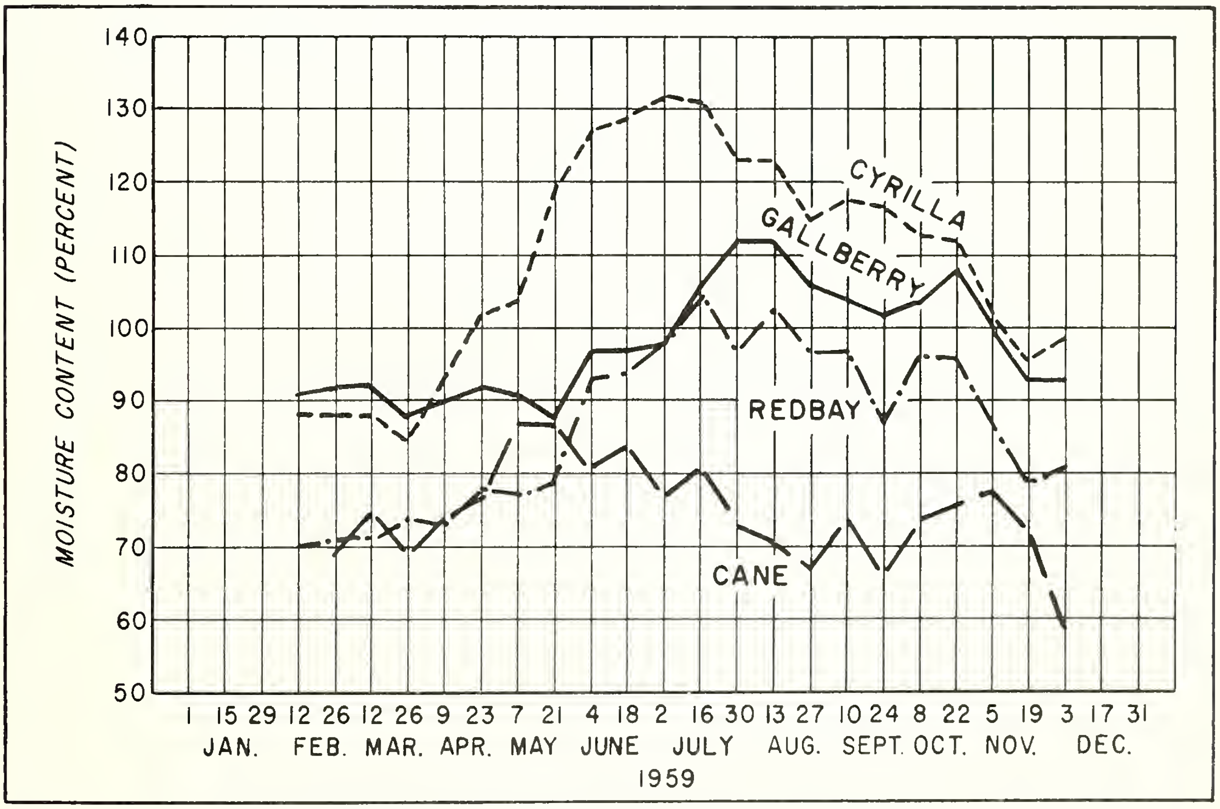


Figure 43.—Whole plant moisture content of common species of understory vegetation on the organic soils of coastal North Carolina.

tent or contained more than 100 percent moisture.

Whether similar differences between seasons and among species will be found in other years is not known. Neither do we know the effect of high or low soil moisture on plant moisture.

Estimating Fuel Weight of Pond Pine Crowns

In a study of fuel classification on organic soils it was desirable to find some rapid means of estimating the contribution of the overstory pond pine crowns to total fuel weight, because tree crowns are not readily accessible for sampling from the ground. In blowup fires even the crowns of tall trees will burn and contribute significantly to total energy released.

The curve in figure 44 may be used to estimate the weight of foliage for pond pine on the organic soils of North Carolina. Correlation was improved slightly when diameter at breast height inside bark was substituted as the independent variable; however, dimensions of the stem inside bark are difficult to estimate or measure.

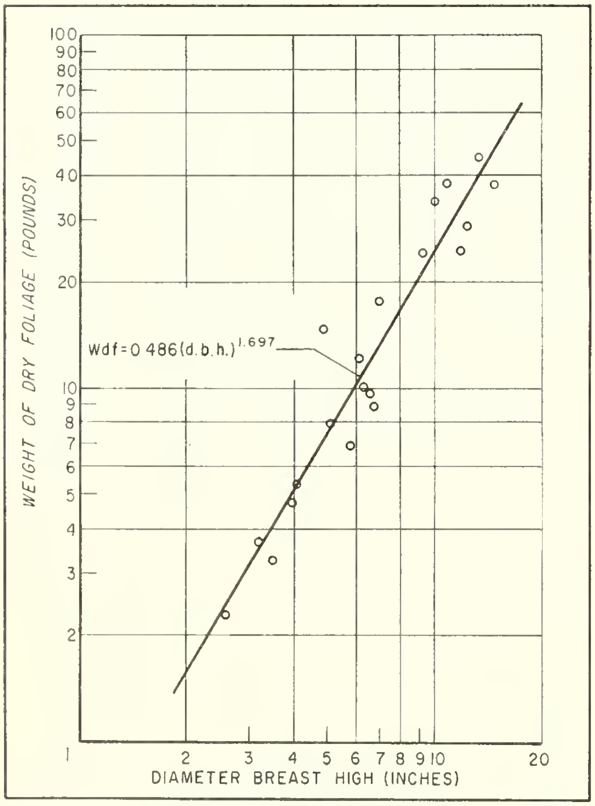


Figure 44.—Relation between the ovendry weight of pond pine foliage and d. b. h.

Because pond pine generally grows in even-aged stands, the contribution of the foliage to total fuel weight can be estimated by determining the average diameter of a particular stand and multiplying the total number of trees by the values read from the estimating curves. For example, a pine overstory averaging 100 trees per acre and 10 inches d. b. h. would contribute 2,400 pounds of foliage to total fuel weight per acre. If the understory vegetation and litter weighed 8 tons per acre —about average for pocosin fuels—the addition of foliage would increase this weight about 16 percent to 9-1/5 tons.

FIRE DANGER MEASUREMENT

Studies of Fuel Moisture Indicator Sticks

Estimated fuel moisture content is a major element in fire danger rating; it is common to all rating systems, although expressed in different ways. All but two regions in the United States use either thin basswood slats or ½-inch pine dowels to reflect the moisture content of lightweight fuels. Some systems require screens over the indicator sticks to simulate a degree of forest canopy shade, others do not. Two regions measure the key weather variables that control fuel moisture and enter this information directly into their fire danger meter.

In the interest of exploring a standard method for estimating fuel moisture for the national meter, a study of fuels and fuel moisture was begun this year at the Southern Forest Fire Laboratory (figures 45 and 46). Current investigations include the measurement of slat and dowel moisture contents to determine the relative response of slats and dowels, the effect of different degrees of screen shading, and whether stick moisture content can be estimated from weather variables with acceptable accuracy.

A number of basic differences have been noted between slats and dowels. The surface temperature of slats is consistently higher than dowels under the same amount of shading; differences are greatest on clear days and least on cloudy days when both surface

Figure 45.—Fuel moisture stick study installation at the Southern Forest Fire Laboratory showing replicated screen shade frames and weather instrument locations. Racks for preweathering slats are in the background and an open-type danger station is in the right foreground.

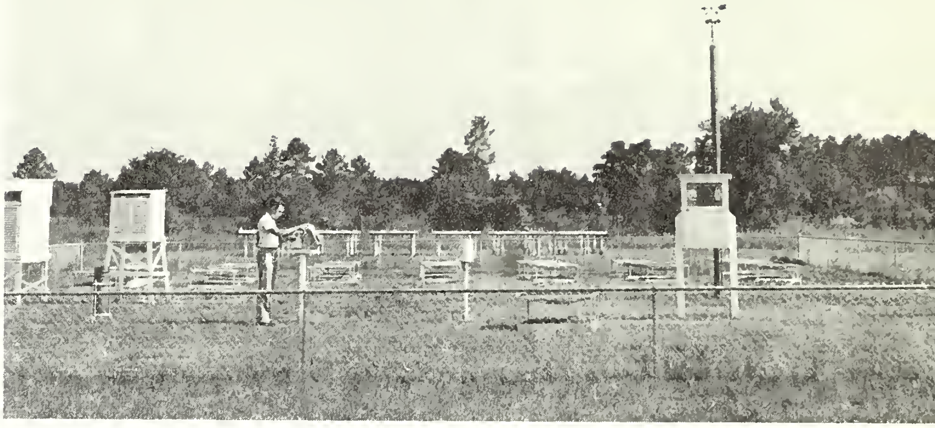


Figure 46.—Test sets of basswood slats and pine dowels under no screens. Other test sets are exposed under 1, 3, 4, and 6 screens.

temperatures approach air temperature. Slat temperatures as high as 127° F. and corresponding dowel temperatures of 116½° F. were measured in the open on clear days when the air temperature was 100° F. The higher temperatures probably result from the difference in geometry and color and associated radiation effects.

For similar reasons, the moisture content of slats invariably is lower than dowels for equal shading; differences are greatest on clear days and the two moisture values approach each other on cloudy days. Slat moistures as low as 2½ percent and dowel moistures of 7 percent were recorded in the open on clear days when the air temperature was 100° F. Dowels respond much more slowly than slats to weather changes, frequently lagging behind slats as much as 10 hours or more.

Both slat and dowel surface temperatures decrease rapidly as screen shading is increased. Temperature differences of 7° F. between 0- and 1-screen and 20° F. between 0- and 6-screens for both slats and dowels are not unusual On this basis we would expect the moisture contents of both slats and dowels to increase with increasing shading and slats to increase the most. Thus, the moisture content of slats under 6 screens may be higher by 1¾ percent compared to slats under 1 screen. Dowel moistures average 1¼ percent higher under 6 screens compared to 1 screen.

The relation between the moisture content of indicator sticks and that of actual surface fuels will be studied under controlled conditions at the Southern Forest Fire Laboratory. Fuel moisture conditions under the various degrees of shading provided by screens will be equated to actual forest conditions by comparing light transmittance under screens and forest canopies.

Bronze vs. Aluminum Screens for Shading Fuel Moisture Slats

The effect of aluminum and bronze screening materials on the moisture content of basswood indicator slats at open-type fire danger stations is being investigated at the Southern Forest Fire Laboratory.

Although our instructions for operating danger stations recommend bronze screens, aluminum screens are widely used because of ready availability and lower cost. Because aluminum remains bright, we thought that slats under screens made of this material might possibly react differently. Analysis of slat moistures under 6 layers of aluminum and 6 layers of bronze screen tested this summer indicated that the differences were statistically significant, but the cumulative differences were so small that almost no effect on buildup and burning index was noted. Some compensating effects are suspected because of the wide differences in reflectivity and absorptivity of the two materials, particularly for long wave back radiation. No definite conclusions can be reached until a full year's data have been analyzed.

Progress in Developing a Unified Fire Danger System

A 1958 joint committee of fire research and fire control men, meeting in Washington, considered the reasons for attempting the development of a unified fire danger measuring system. The committee explored possible approaches and suggested a development program. Following the committee recommendation, a staff position was created in the Washington Office Division of Forest Fire Research, and John Keetch was assigned to the project with field headquarters in Asheville, North Carolina. Work got under way in the fall of 1958.

By mid-1959 a field survey of the needs and uses of fire danger data was completed for each region, including an on-the-ground study of all the fire danger systems in current use. The study verified that all fire danger systems are based on weather influences, but that there are large differences which stem from lack of a common basis for interpreting weather changes. To meet field needs a national system must be flexible enough to serve organizations requiring only a general guide, or a single index, as well as those who regularly use fire danger data in many ways, from timing and evaluating fire prevention effort to initial attack planning on specific fires.

In developing the national system attention was focused on the problem of establishing servicewide fuel standards. Since regional fuels commonly range from thin grass blades in the open to large logs under the forest canopy, the separation of this tremendous response-range into meaningful segments is no simple task. Preliminary research indicates that it should be possible to identify fuels that

belong to a particular drying regime in terms of their relative drying rates, providing a standard drying potential (weather) is maintained. A suggested standard for identifying surface fuels and an outline of the research needed to test the standard and to develop a method of measurement was completed by midsummer.

At a meeting of the fire danger advisory committee it was agreed that an attempt should be made to complete the framework of a trial system by the summer of 1961 to be followed by a 2-year testing program, with the objective of having the unified system ready for field use by 1963. It will not be possible to complete all of the needed research within the time schedule. Thus, the committee urged that a preliminary national system should be designed insofar as possible with sufficient flexibility so that improved relationships can be added as they become established through additional research.

PRESCRIBED BURNING STUDIES

Periodic winter backfires in the coastal plains of the Southeast reduce fuel accumulations considerably, but the reductions, particularly in the weight of live vegetation, are rather short-lived. Litter weights on the Osceola National Forest in Florida one year after prescribed fires in roughs at least 5 years old were about 42 percent of their original weight. On the Francis Marion National Forest in South Carolina in similar-aged roughs, litter weights were about 55 percent of their original weight one year after burning. Vegetative accumulations (gallberry-myrtle-bay fuel type) on the Francis Marion had built up to their original weight within one year after burning, even though plant heights remained at a lower level. On the Osceola (palmetto-gallberry fuel type), vegetative buildup of this proportion required a 2-year period.

Temporary reduction of fuel accumulations by periodic winter backfiring may play an important part in keeping the number of large fires to a minimum. Fires are difficult to start in stands where litter is sparse and they seldom reach high intensities where vegetation is light or lacking.

On a study area of about one million acres in south Georgia and north Florida, the effect of age of rough on the nature and frequency of wildfire occurrence was investigated. Data were collected from 374 fires on 954,000 acres for 4 years, 1955-58, a span which included two bad fire years, one easy year, and a moderate year (fig. 47). Although a higher occurrence rate was indicated for the roughs 3 years and older, the differences were not extreme.

On the other hand, the differences in burn acreage, particularly between the youngest and oldest roughs, were extreme. Twelve fires of over 200 acres occurred on the study area during the 4 years considered and all of them originated and burned in the older roughs.

The effect of repeat fires of varying intensities on fuel reduction is being studied on the Waycross State Forest in south Georgia. Following a normal winter prescribed backfire, successful summer and fall burns were achieved by strip firing techniques where litter weights averaged at least 3 tons per acre (fig. 48), fuel moisture content ranged from 6 to 14 percent, and variable winds averaged 2 to 5 miles per hour. Litter accumulations of less than 3 tons per acre failed to carry any type of operational fire under the weather conditions encountered.

When fuel accumulations were heavy, as for example in the initial winter burns in 15-year-old palmetto and gallberry roughs, head fires (in strips) and backfires reduced litter weights about 60 percent. When fuel accumulations were light, as found in repeat burning, and the same range of weather conditions prevailed, backfire burning was unsuccessful.

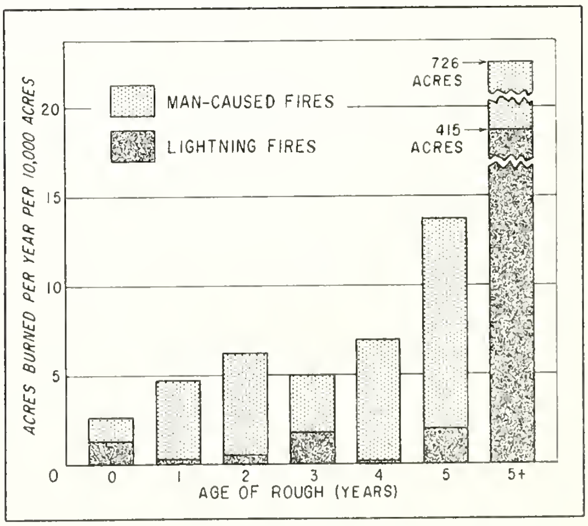


Figure 47.—Average annual number of wildfires.

Figure 48.—Litter is collected from sampling units to determine the weights of available dead fuel.

Strip fires, however, performed satisfactorily, and consumed another 55 percent of the remaining litter. The effect of repeat burning on vegetation will be determined following the spring burns.

In 8-year-old palmetto and gallberry roughs of the coastal plains, heat peaks of 1600° and 600° F. were obtained for summer head fires and backfires, respectively (fig. 49). In typical Piedmont fuel types on the Hitchiti Experimental Forest that had been free of fire for at least 10 years, heat peaks of 1000° and 500° F. were obtained. The Btu outputs from head fires and backfires in the same fuel were essentially equal, even though the backfires required at least twice as much time to reach their potential.

Moisture Content of Aerial Fuels

Samples of palmetto, gallberry, wiregrass, and slash pine needles were collected biweekly from a timbered area in the lower coastal plains of Georgia to detect possible moisture content fluctuations and the probable causes.

Preliminary findings show the presence of fluctuations but fail to tie them in directly with any of the measured weather elements. Rather, physiological processes within the plants appear to be responsible for the variations. During the 6-month period from July to December, the highest moisture contents for all samples were measured in July, followed by fluctuating declines in August and a very stable period from September to December. Moisture content of pine needles, averaging about 175 percent of ovendry weight, remained consistently higher than other material; the moisture content of wiregrass, averaging about 50 percent of ovendry weight, was lower than other material.

The higher moisture contents and the greatest fluctuations in moisture content were measured in the foliage of the plants under observation, with the exception of palmetto. Palmetto fronds exhibited greater fluctuations than the stems, but contained less water.

AERIAL FIRE RETARDANTS

Monoammonium phosphate solutions, dropped from a TBM aerial tanker for the first time in 1959, appear to be the most effective aerially delivered fire retardants in use at the present time on coastal plains vegetation in the South. Fast-moving head fires in heavy fuels were stopped along lines at least 175 feet long as a result of 220-gallon aerial drops (figures 50 and 51). A fertilizer containing 12 percent nitrogen and 61 percent P_2O_5, the material is not toxic to plant life and goes into solution with water readily. When compared with other retardant mix-

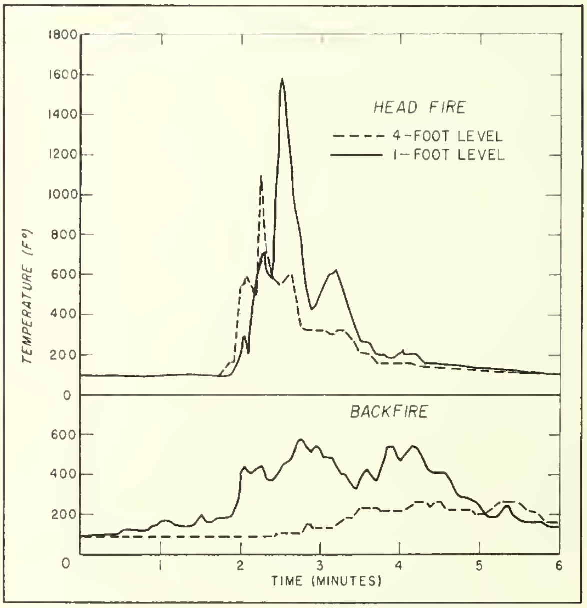


Figure 49. — Time-temperature recordings for head fires and backfires in 8-year-old palmetto and gallberry roughs.

tures, it is relatively light in weight—9.1 pounds per gallon at 15 percent concentration.

The application rate needed to stop a fire was estimated to be about 1 gallon per 100 square feet of ground area. This protection was effective until the material was washed from the vegetation by rain or heavy dew.

Further tests with sodium calcium borate, another good fire retardant, indicate that borate slurry is toxic to some southern vegetation. Loblolly pine and sweetgum seed failed to germinate when the germinating media were treated with borate applications of 3 and 6 gallons per 100 square feet. When borate is applied extensively at application rates of at least 3 gallons per 100 square feet over a tree's root area, mortality may be expected in all tree sizes (fig. 52). Weak application rates on a limited soil area or restricted to the foliage are usually not fatal to trees, although dieback or growth loss may occur.

Further calibration of the TBM aerial tanker showed that approximately 80 percent of the slurry was accounted for when dropped in 220-gallon or 440-gallon loads in an open area from an altitude of 85 to 100 feet at a plane speed of 110 knots. The remaining 20

Figure 50.—Fast-moving head fires in heavy fuels were used to test the effectiveness of different fire retardants.

percent was probably lost as evaporation or dissipated as fine mist. Total drop lenth, where the dropped material fell in measurable quantities, extended 400 feet or more. However, that part of the pattern length with application rates of at least 1 gallon per 100 square feet seldom exceeded 250 feet in length. The 1-gallon zone conforms closely to the effective length of fireline made by a 220-gallon drop.

Drops through a 20-year-old pine stand with a 60 to 70 percent crown closure showed that the crowns themselves will intercept about 30 percent of the material. As a result, larger drop loads are required in timbered areas than in the open. In relatively open areas (poor tree stocking), 200- to 300-gallon drops of effective retardant material will stop most fast-moving surface fires along a 200-foot front. On the other hand, where tree stocking is heavy and tree canopies intercept considerable material, drops of at least 400 gallons are necessary to get the same effective 200-foot fireline.

Figure 51.—Test fires were stopped by monoammonium phosphate.

Figure 52.—Longleaf pine trees in the center of a drop area may be killed as a result of heavy borate applications.

MISCELLANEOUS

Our Southern Forest Fire Laboratory at the Forestry Center near Macon was formally opened by Governor Ernest Vandiver on November 4.

As a result of the Division's suggestion at the conference held in Washington to discuss Form 929 fire report revision, a supplemental form is being devised on which fire behavior information will be recorded for fires 300 acres or larger.

Several members of the Division attended an international symposium on fire modeling in Washington in November. The conference was sponsored by the Committee on Fire Research of the National Academy of Sciences, National Research Council.

A comprehensive study of fire danger rating and its applications in Georgia is under way. Forty key stations have been selected and are being checked periodically by members of the Division. The first year's records of danger and fires are ready for analysis.

Two additional sites have been selected and crews trained in operating pilot balloon installations. They will be located in the coastal plain of North Carolina and Georgia and will be operated by state personnel. The purpose is to detect low-level jet activity that has frequently been found associated with severe fire behavior.

Detailed fire-weather forecasts for the State of Georgia were prepared routinely again this year by the U. S. Weather Bureau Meteorologist assigned to the Laboratory. Studies are planned on forecasting very low humidities and determining the most persistent wind directions for prescribed burning.

H. E. Adams has been assigned by Region 7 to replace J. J. Keetch. He is stationed in Asheville and is responsible for assisting states and national forests in the operational aspects of danger measurements and their application.

FOREST UTILIZATION

Two far reaching developments mark the 1959 utilization picture. One is the greatly expanded use of hardwoods for pulp, both in round wood and chips. The second is the development of sparse tooth saws that permit the use of saw chips (coarse sawdust) for pulp. These developments are new-born, so to speak, but should grow to be important facets of the wood utilization field in the years to come. Their fruition is the result of efforts of many scientists and industry people, working together towards a common goal.

Outside Storage of Pine Pulpwood Chips

Many pulp companies in the South buy pulpwood in the form of chips from sawmills and other wood-using industries. Perhaps the most economical way to store these chips is in outside piles. Pulp companies in the West have been storing chips in the open for periods up to 4 years with practically no loss from deterioration. In the warmer and more humid climate of the South, however, it is possible that serious deterioration of chips stored in the open may occur in a relatively short time.

The Station entered into a cooperative agreement with St. Regis Paper Company in the spring of 1959 to develop information on open storage of pulpwood chips at their Fargo, Georgia, yard.

It was agreed that the determination of factors causing deterioration and volume losses would be reported by the Forest Products Laboratory and the results of pulp quality tests by the Technical Department of St. Regis Paper Company.

A pile of freshly cut chips approximately 70 feet long, 40 feet wide, and 8 feet high was built on a 50 x 100-foot asphalt apron by a dump truck and D-2 Caterpillar tractor with blade (fig. 53). The action of the tractor over the pile served to compact the chips.

Samples were collected randomly as the pile was constructed and at 20 predetermined points in the pile profile 2 weeks later, and again in 1, 2, 3, 4, and 5 months. Green and air-dried chips from each sample were sent to the Laboratory for analysis, other green chips were weighed and ovendried for moisture content determination at Macon, and still others were sent to St. Regis at Pensacola for pulping tests.

A new pile profile was formed at each sampling by removing both the chips forming the angle of repose at one end and a 4-foot cross section of the pile. After samples were collected, surplus chips were pushed back over the front of the pile to reform the angle of repose (fig. 54).

Thermocouples were placed at 12 locations throughout a cross section of the pile that was to be torn down last so that temperatures within the pile could be plotted over the storage period. Temperature readings were taken daily when possible.

Weather data were collected from a recording hygrothermograph located near the pile, from a rain gage at a nearby fire tower, and from a recording anemometer placed on top of the pile.

Moisture content (ovendry basis).—The initial moisture content of the chips in the pile ranged from 91 to 116 percent. The moisture content of the surface layer increased to 140 percent as early rains wet the pile. The moisture content of the pile from surface to innermost sections gradually increased and at the end of 4 months the pile was fairly uniform with an average moisture content of 130 percent.

Temperature.—Almost immediately after the pile was erected, temperatures began to rise. After one week, the average temperature of the outer 2-foot layer of chips was just below 100° F. After 2 weeks, temperatures reached 131° F. 2 feet beneath the surface. For the duration of the study, the majority of the chips, excluding those in the side layers, did not fall below 90° F.

Stain.—In the last profile uncovered 146 days after the pile was built, the only heavily stained areas were those where temperatures fell below 90° F. Areas free from stain coincided very closely with the zone of temperatures above 90° F. (fig. 55). Temperatures may have been high enough for a sustained period to prevent the growth of blue stain fungi.

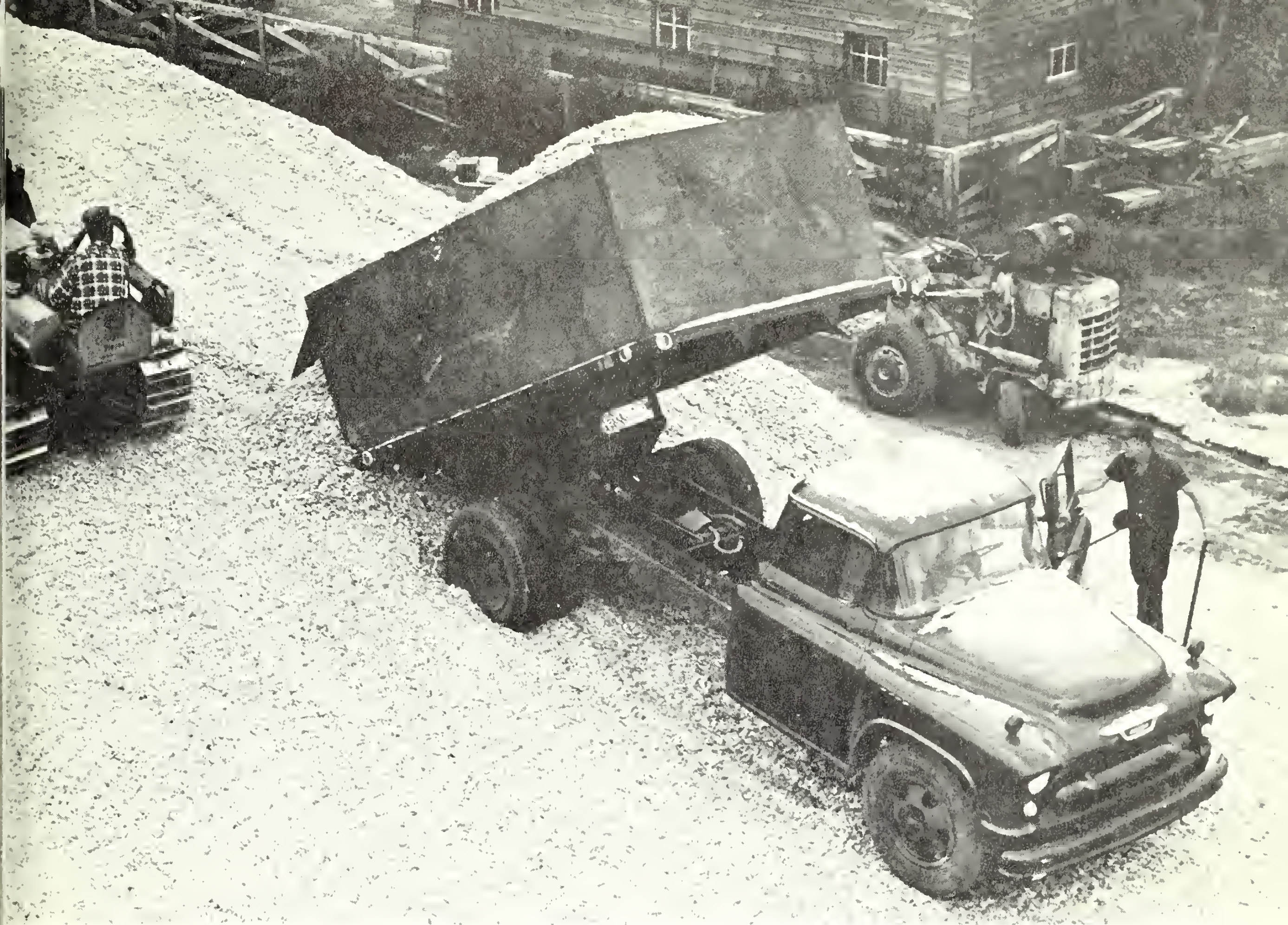


Figure 53.—Fifty-nine dump truckloads of chips were used to build the pile.

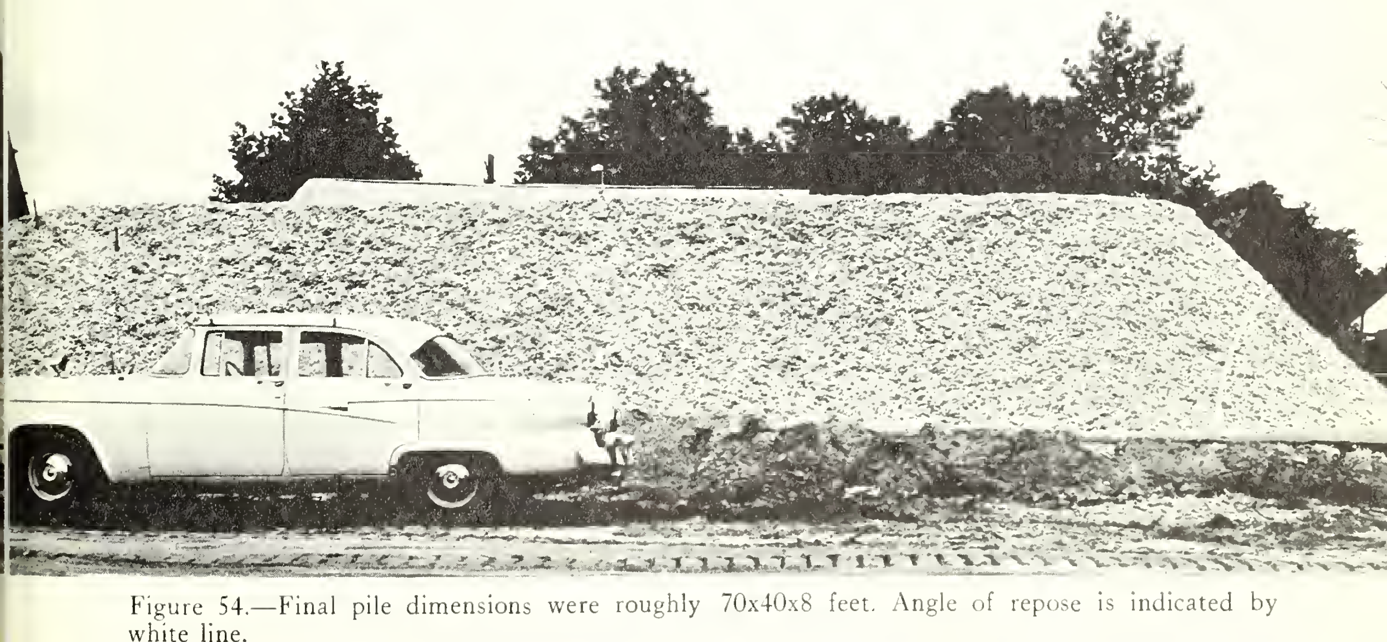


Figure 54.—Final pile dimensions were roughly 70x40x8 feet. Angle of repose is indicated by white line.

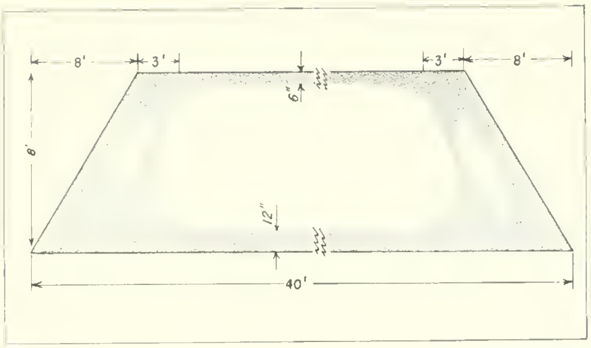


Figure 55. — Chip storage study pile after 5 months of open storage. The shaded areas indicate the location of prominent staining.

Specific gravity.—The periodic loss of specific gravity is shown in table 13.

Winter data are now being obtained from a second pile built on the same ramp in November 1959.

In summary, the most significant trend revealed by the moisture data is the progressive increase in moisture content with longer storage periods. Softness and brashness of dark stained wood were first evident in a few samples stored 13 weeks, and became increasingly common with longer storage periods. The appraisal of typical decay in the chips was complicated by the prevalence of dark stain.

Only minor reductions in specific gravity were shown for storage periods up to 8 weeks, and fungus infections apparently were not the primary cause of such reductions. For storage periods of 13 and 21 weeks, average specific gravities were 96 and 93 percent, respectively, of the average for green chips.

Table 13.—Condition of chips at sampling intervals

Time in storage	Specific gravity 1/		Average moisture content	
	Green	Air dry	Field measurement	FPL measurement
			- - Percent - -	
Initial	0.510	0.506	101	98
2 weeks	.505	.508	95	96
4 weeks	.498	.506	88	95
8 weeks	.492	.501	119	120
13 weeks	.484	.493	128	131
17 weeks	.479	.486	133	135
21 weeks	.467	.476	115	147

1/ Based on volume and weight when ovendry.

Methods of Sawing Pine for Grade

There are several accepted methods of sawing pine logs for grade. This study was designed to evaluate these methods by theoretically resawing selected logs and determining grade-yield by three methods of orienting visible knot defects on the cutting faces, and by four ways of turning the log.

A technique was developed using photographs of each board live-sawn from the study log (fig. 56), and a full scale end section diagram showing all the knot defects as they radiate from the pith. With these two planes available, plastic overlays containing theoretical saw cuts can then be placed over the end section and the boards imaginarily produced in this manner can be graded according to SPIB grading rules. The overlays may be turned to change the position of knots on the sawing faces. The boards can then theoretically be cut in the new position, graded, and total log values compared with values obtained by other defect orientation methods.

The three defect orientations under study are centering visible defects, cornering visible defects, and cutting the clear face of the log first. The four turning techniques are: (1) cut faces 1, 2, 3, and 4 in that order; (2) cut faces 1 and 3 and live saw the cant; (3) cut faces 1, 2, and 3; and (4) live saw the log. Data are obtained on the number of cuts removed from each face before turning the log to the next cutting face. These data are compared by each variable mentioned and log values are determined.

Twenty-three logs have been cut and are in various stages of processing. Comparative data obtained for two logs will serve as an example. The quality indices in the "Interim Log Grades for Southern Pine" were used with a base price of $78 per M board feet for No. 2 common lumber. Both logs were No. 2 grade and were 13.5 inches and 16.5 inches d. i. b., small end. The various sawing techniques tested by theoretically resawing the same logs produced lumber ranging from $108 to $135 per M board feet for the small log and from $133 to $168 per M board feet for the large log. In this case the spread was from $108 to $168 per M board feet for the same grade logs.

The number of boards removed from the sawing face before turning the log can produce a significant spread in lumber values. For example, the 16.5-inch log sawn clear face first and turned to cutting faces 2-3-4, in that

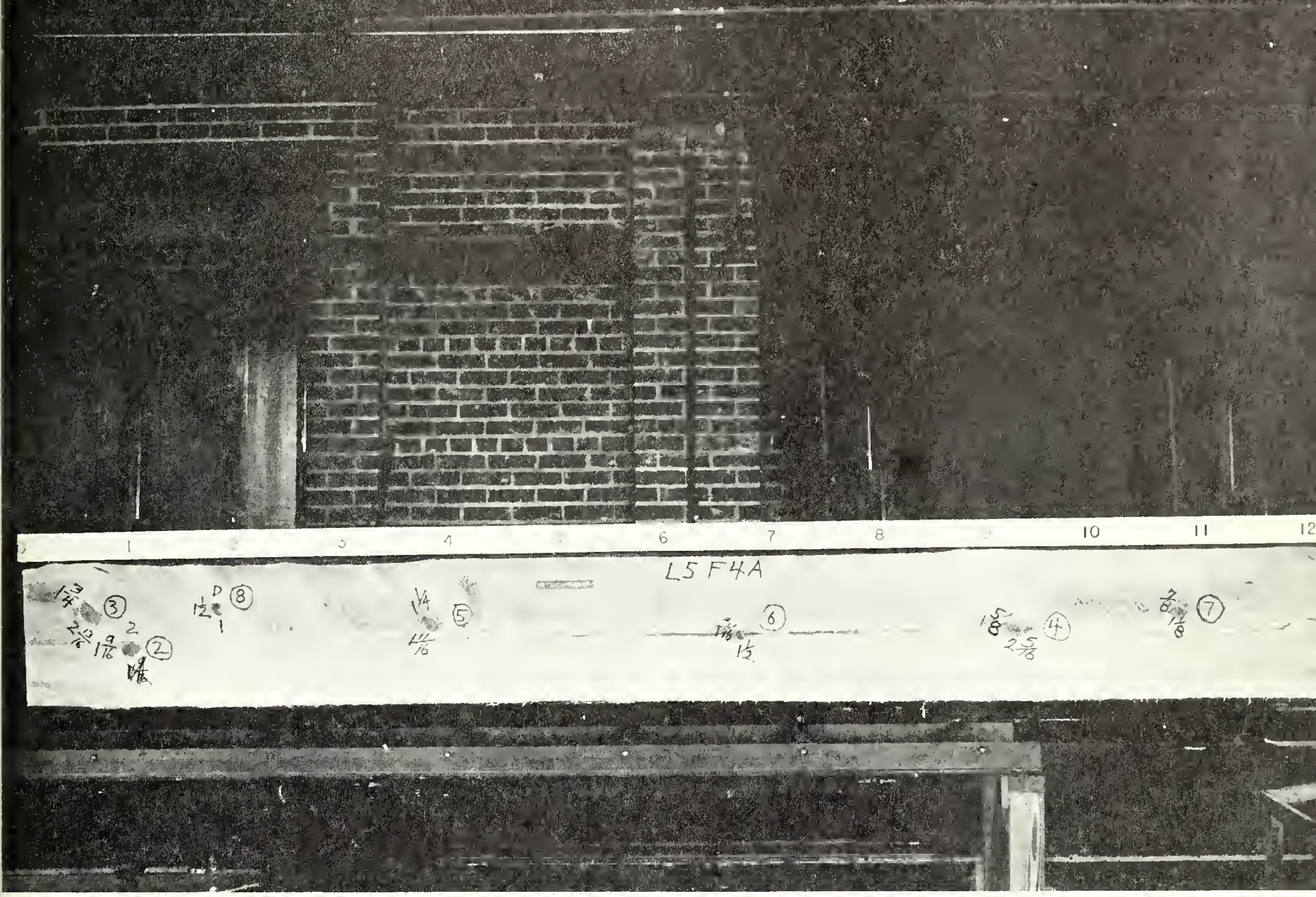


Figure 56.—Method of marking and then photographing defects on each board as the log is live sawn.

order, produced lumber valued at $158 per M board feet when 6 cuts were removed from the first face and 3 cuts from the second, and the remainder from faces 3 and 4. If only 2 cuts were taken on the clear face and 5 cuts on face 2, the value of the lumber would be only $145 per M. Any other combination of boards removed from the clear face would produce lumber between these two values.

The sequence of sawing the log faces also produces a variety of lumber values. The 16.5-inch log was theoretically resawed 56 times by keeping a constant of "cornering visible defects," but using 4 turning techniques. The remaining variables relate to the number of boards cut from each face before turning for each of the turning techniques. The lumber values ranged from $152 per M board feet to $168, provided the optimum method of removing boards from each face for each turning technique is used. The poorest method of removing boards per face for the same turning techniques produced lumber valued from $132 to $144 per M.

Quality of Pulp Chips Made from Coarse Sawdust

The use of large volumes of sawdust for making pulp is of economic importance to the landowner, the sawmill operator, and the pulp and paper industry. Short fiber length in sawdust particles has been the major obstacle in its use as a raw material for making pulp.

In 1959, the Forest Products Laboratory in cooperation with the Station agreed to test several sparse-tooth saws with 12, 18, and 36 teeth. These tests included behavior of the saw at various revolutions per minute and rates-of-feed in producing a range of lumber widths, as well as such factors as power requirements and quality of lumber sawn. They also included pulping tests on chips of standard size produced in a chipper, sawdust chips produced by the 36-inch saw, and saw chips produced by a prototype of the 12-tooth saw in a commercial sawmill.

The first of the saws tested was obtained from J. T. Griffin of Valdosta, Georgia, and was developed jointly by the sawmill owner and a saw manufacturer. The Forest Products Laboratory ran pulping tests on coarse sawdust produced by these sparse-tooth saws.

The sawdust used in these pulping tests had an average particle length of ¼ inch in the fiber direction. It was separated into two fractions by a screen with round openings 3/16 inch in diameter. The sawdust remaining on the screen was termed "sawdust chips" and the sawdust falling through the screen, "sawdust chip fines." Sawdust chips produced from other logs by a 12-tooth saw blade at a commercial sawmill in Georgia were also tested.

Yields of kraft pulps made from commercially produced sawdust chips and from the Laboratory sawdust chips, either alone or in mixture, were not significantly different from yields from conventional chips. Chlorine requirements for bleaching were within the normal range for kraft pulps. Results indicated that coarse sawdust chips were slightly easier to pulp than conventional chips. However, the sawdust chip fines were less readily pulped.

Both bursting and tearing strengths decreased as the wood particles became smaller. However, strength properties of pulp from sawdust chips indicate that these were sufficiently strong for use alone or in mixture in many kraft papers.

Preservative Treatment of Turpentined Poles

Companies that purchase longleaf and slash pine poles for preservative treatment have differing acceptance practices for bark-chipped acid-treated poles, predicated on the varying experiences they have had with penetration and retention of preservatives in the area of the turpentined faces. Exploratory penetration and retention tests on turpentined poles were made in south Georgia in 1948 and again in 1957, but results were erratic, and indicated the need for more study.

In view of this need, the Langdale Company offered to cooperate with the Southeastern Forest Experiment Station and the Georgia Forestry Commission in a third study which would involve poles seasoned for different lengths of time and treated with and without initial steaming. The first phase of this study involved a single species, slash pine, and was completed this year.

A representative sample of turpentined poles (fig. 57) was seasoned for various lengths of time, treated with creosote by the usual commercial practice, and tested for penetration and absorption in the turpentined faces (fig. 58). Moisture content and penetration determinations were made by Station personnel and retention analysis was conducted by the Wood Preservation Division of the Forest Products Laboratory.

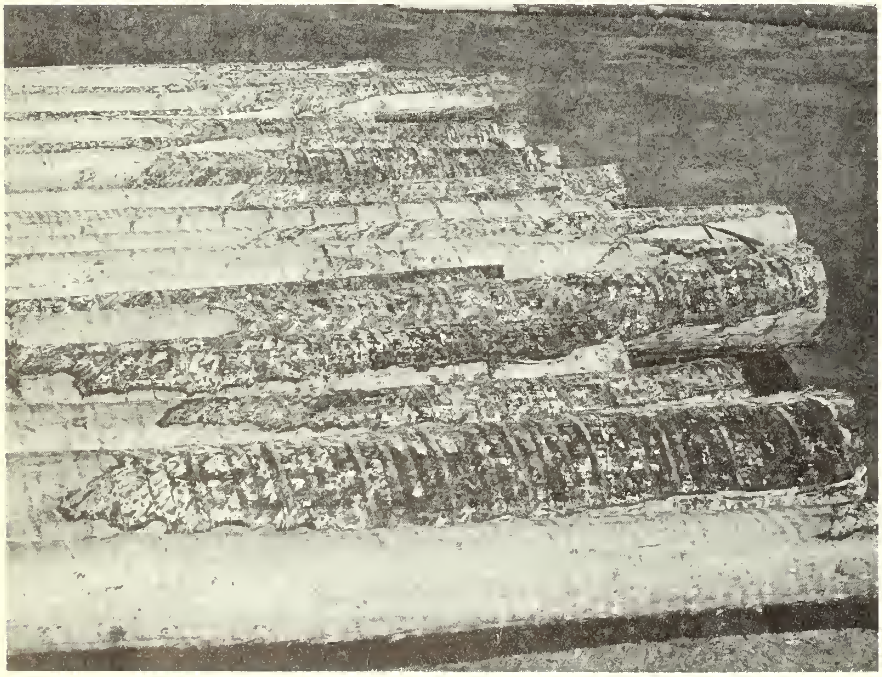


Figure 57.—Turpentined faces on utility poles used in this study.

Figure 58.—Random selection of test cores from the acid-treated faces.

A total of 80 poles was treated; 20 green, 20 air-seasoned for 30 days, and 40 air-seasoned for 90 days. Of the 40 seasoned for 90 days, 20 were not steam treated prior to preservative treatment. All poles were treated for a retention of 10 pounds per cubic foot except those seasoned for 90 days and not steam conditioned. These were treated for a retention of 8 pounds per cubic foot.

Data indicate that all poles air-seasoned 30 and 90 days and steamed before treatment were adequately penetrated with preservative. The green poles that were immediately steamed and treated had 7 out of 20 poles with unsatisfactory treatment, and the 90-day air-seasoned and unsteamed poles had 14 out of 19 poles with unsatisfactory treatment.

A similar study is now under way with longleaf pine poles seasoned for 30 and 90 days and steam-conditioned before treating. A final report of this project will be prepared when data from the longleaf pine study are available.

A Problem in Mismanufactured Lumber

The furniture manufacturers of North Carolina have been acutely aware that a serious problem exists in the large volume of mismanufactured lumber received at their plants. This fact was emphasized in 1955 when a study showed that approximately 10 percent, or 14 million board feet, of the lumber received was outside specifications. This meant rejection or remanufacture at considerable expense to the furniture industry. A second study was made in 1958 to determine the volume of mismanufactured lumber received at North Carolina furniture plants under revised NMLA rules which call for tighter restrictions on thickness specifications.

Ten furniture plants were selected for sampling on the basis of geographic location and the amount of lumber received. Five individual samples, each from a different supplier, were taken at each of the ten plants.

A sample from each load consisted of 50 randomly selected boards. Every board, 2,500 in all, was calipered in six places for thickness, measured for length and width, and graded. The lumber was then classified as nominal or mismanufactured; the latter category included all rough, green, hardwood lumber that was miscut, oversize, or scant (fig. 59).

An 11.0 percent sample was taken from the 50 loads of lumber. In board-foot measure, this sample amounted to 14 M board feet taken from a total volume of 125 M board feet. Of the 14 M board feet, 30 percent by volume (4,200 board feet) was found to be mismanufactured. Table 14 shows the percentage breakdown of mismanufactured lumber according to the various classes studied.

On the basis of these findings, and knowing that North Carolina furniture plants purchase approximately 140 million board feet of sawn hardwood lumber per year, it can be assumed that about 42 million board feet of this lumber is mismanufactured over the same period. These facts point out the magnitude of the problem.

In an effort to alleviate the problem, future work will be aimed at case studies of sawmills manufacturing at low levels of precision and efficiency. This will involve determining the most common sawing, edging, and trimming errors with subsequent corrective action, and will lead to an effective program of instruction through sawmill clinics.

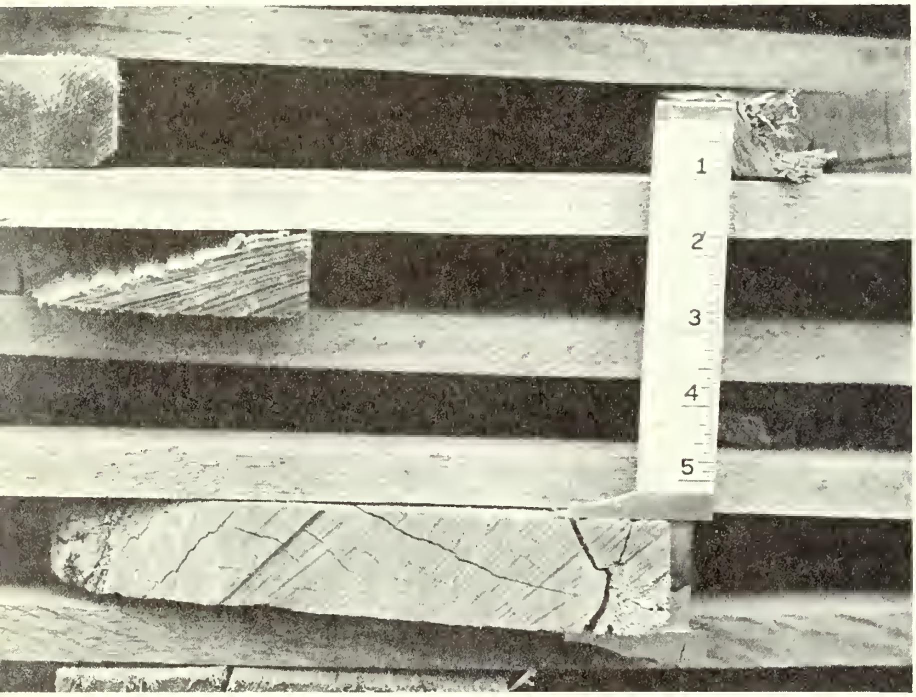


Figure 59. — Wedge-shaped boards are termed "miscut." They cause undue waste and place an extra burden on planer knives.

Table 14.—Relative volume of nominal and mismanufactured lumber received at North Carolina furniture plants

Class of lumber	Percent of volume 1/
5/8, 3/4, 4/4, 5/4, and 6/4 nominal	70.0
Oversize	8.6
Thin	4.8
Miscut	16.6
Total	100.0

1/ Based on sample of 50 loads of lumber.

Tensionwood in Hickory

In cooperation with Clemson Agricultural College, several studies have been completed on tensionwood in hickory. The first study showed that hickory trees which split severely contained greater amounts of gelatinous fibers than trees which did not split. Because this difference was statistically significant, it is assumed to be a true difference. Also, the distribution pattern of tensionwood in splitters and non-splitters was found to be somewhat different.

A second study showed gelatinous fibers in relatively large amounts over the entire cross

section of a straight, severely split tree. Four radii were examined at each 8-foot interval along the merchantable length of the tree. Gelatinous fibers were found in almost all annual rings on all four radii at all levels except the stump. In this study, the nonsplit trees, of which one leaned and one did not, showed a concentration of gelatinous fibers on the upper side of the lean, which is typical of the distribution in a leaning tree.

In 1948 Jacobs showed that greater stresses are developed in tensionwood than in normal wood. In view of this, it is probably reasonable to assume that relatively large amounts of gelatinous fibers, distributed more or less uniformly throughout the cross section of the tree, contribute to the development of internal stresses which are severe enough to cause excessive splitting.

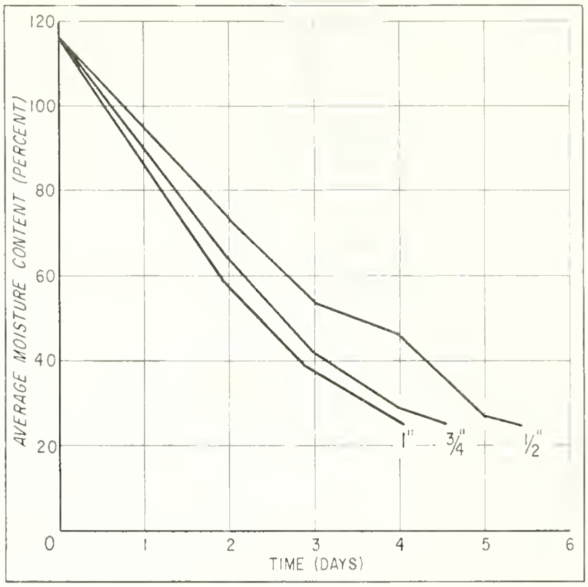


Figure 60.—Effect of sticker thickness on drying time of 4/4 southern pine lumber.

Forced-Air Drying of Lumber

Research in forced-air drying of 4/4 pine lumber at Athens was described in the 1958 annual report. This work was done in a converted dry kiln and in specially constructed wind tunnels.

Additional tests were made using thin stickers. Tests conducted simultaneously in 3 wind tunnels using 1-inch, ¾-inch, and ½-inch stickers show that drying time is increased with thinner stickers (fig. 60). These differences, however, may not be important when compared with the increased volume of lumber in the predrier. Further studies are needed to weigh all factors, such as greater power consumption, air blockage when warping occurs, and sticker breakage.

Replications have confirmed the 1958 tests and all data are now being prepared for publication. As a part of the over-all predrying study, initial testing of a commercial forced-air drier (fig. 61) near Athens was begun this past summer. This drier has a capacity of 30 M board feet of 4/4 lumber and provides cross circulation with automatic fan reversal at set intervals. Supplemental heat is supplied by a fuel oil burner which is controlled by a humidity-sensing instrument. In the initial summer tests, rough green and partially seasoned 4/4 pine was dried in 6 days to an average final moisture content of 18 percent without supplemental heat. Air velocities averaged 600 feet per minute. More studies are under way on the use of additional heat and the cost of drying.

Figure 61.—Pilot plant forced-air lumber drier at Athens, Georgia.

Pine Log and Tree Grade Studies

Separate log and tree grade studies of pine have been conducted during the past 10 years in South Carolina, Georgia, Florida, Mississippi, and Arkansas. Variations in grade yields for similar logs at these separate locations could not be accounted for by measured variables. The difference in sawing techniques and difference in lumber grading provided a possible clue to the variations.

In 1959, trees were collected from each of the original study locations and shipped to an efficient mill in south Georgia where the sawing and grading variations could be eliminated. The data obtained in this study are still under intensive analysis but results obtained so far indicate much less variation than occurred in the original studies.

Using grade 2 logs of similar size and defect pattern, it was found that only one area (Mississippi) resulted in appreciable variation in lumber grade yields (table 15). Further analysis is needed to determine the importance of this variation. In general it appears that the grading system can be used with reasonable confidence throughout the range of the species without the need for local grade-yield studies on each appraisal area, and that differences in sawing techniques can cause much greater variation in lumber grade recoveries than differences caused by geographical locations.

Wood Moisture Content in Homes

Since 1957, the Station, with the cooperation of the Southeastern Dry Kiln Club, has collected data on the equilibrium moisture content of wood in homes throughout the Southeast. This past year, the club began recording moisture content of semi-finished and finished specimens in addition to the unfinished specimens. These two new sets of specimens were coated with a furniture finish; the semi-finished were given coats on three sides with the fourth side uncoated, and the finished were coated on all four sides. When these specimens are located in different areas of the home, they will in effect simulate finished furniture by reflecting the changes in moisture that furniture undergoes.

When moisture content data for the unfinished, semi-finished, and finished speciments were plotted, the semi-finished and finished speciments showed a slower reaction to changes in moisture conditions. This effect was expected because finishes tend to retard the gain and loss of moisture of wood. The following average moisture contents taken over the last six months of 1959 help to substantiate this point. The averages or midpoint of ranges are: unfinished, 10.3 percent; semi-finished, 8.5 percent; and finished, 8.4 percent.

Typical conditions in the living area and basement of a home in Virginia are shown in figure 62.

Table 15.—Variation in lumber grade recovery from No. 2 pine logs from five states

Source of logs	Species	Average age of trees	Average site index	Recovery by lumber grades					
				B & B	C	D	1C & 1 Dim.	2C & 2 Dim.	3C & 3 Dim.
		Years		Percent					
Georgia	Loblolly	63	73	20	12	20	28	14	6
South Carolina	Loblolly	59	85	14	9	21	31	20	5
Arkansas	Shortleaf	72	73	20	12	27	27	14	0
Mississippi	Loblolly	66	73	44	9	13	25	6	3
Florida	Longleaf and slash	73	60-82	21	12	17	36	10	4

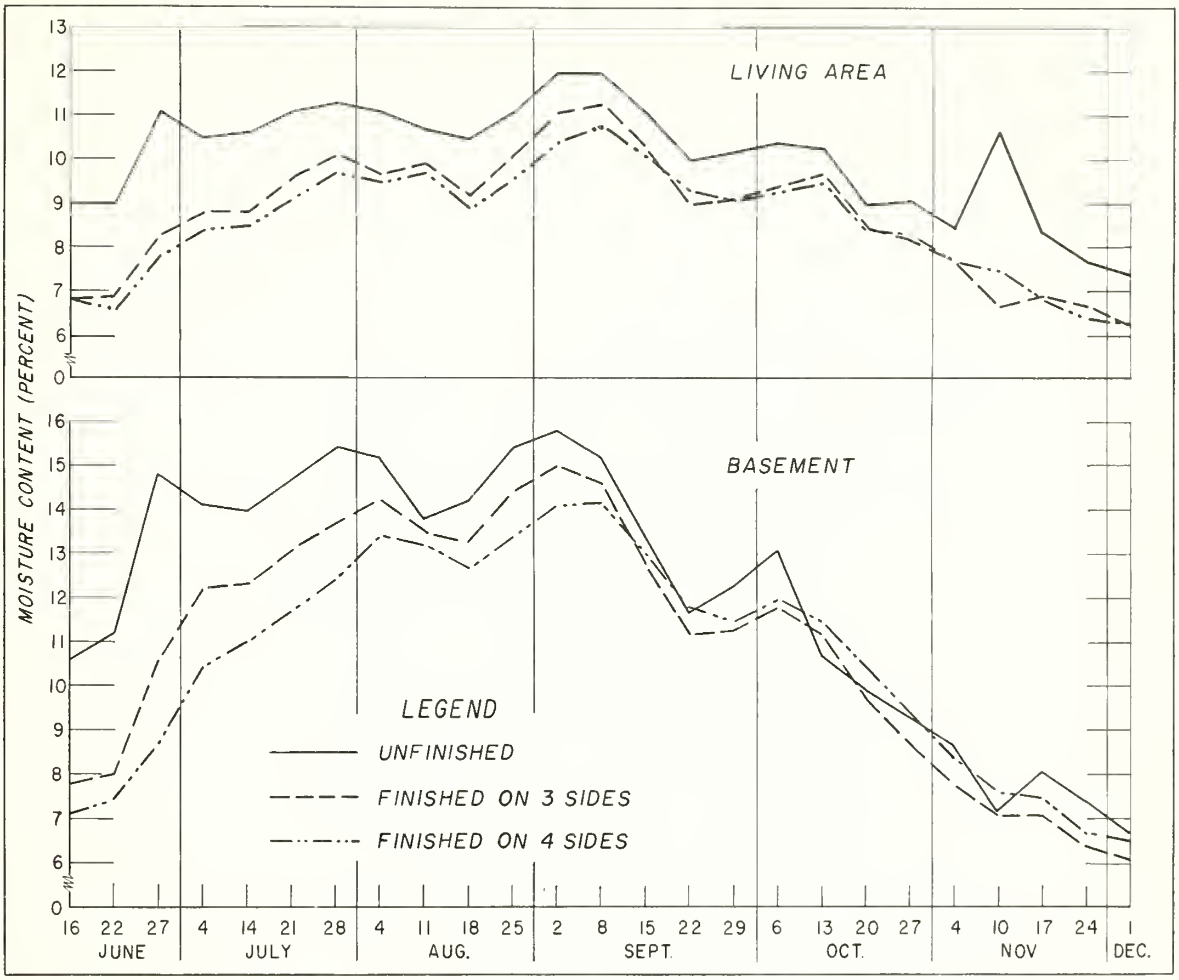


Figure 62.—Variations in moisture content of wood in the living area and basement of a home in Marion, Virginia.

Source of Furniture Lumber

The 1958 survey of the source of lumber for North Carolina furniture plants is the second one conducted through the cooperative efforts of the Furniture, Plywood and Veneer Council of the North Carolina Forestry Association and the Southern Furniture Manufacturers Association. The first survey was made in 1953.

Fifty-four concerns which manufacture 62 percent of the furniture produced in North Carolina reported volume of lumber received by species and source. These volumes were expanded to an industry-wide total on the State level.

Results show that the furniture plants of North Carolina received a total of 321.5 million board feet in 1958. Of this amount, 305.4 million board feet came from domestic sources and 16.1 million board feet from foreign sources. Approximately 45 percent of the domestic lumber comes from North Carolina (fig. 63), another 30 percent from the adjoining states of South Carolina, Georgia, Tennessee, and Virginia, and the remaining one-quarter from the Deep South and central states. A small percentage is brought in from other areas of the United States.

Yellow-poplar accounts for 37 percent of the domestic lumber used (fig. 64), the gums 19 percent, oaks 12 percent, maples 7 percent, and yellow pine 5 percent. No other single species accounts for more than 4 percent of the volume.

About half of the domestic lumber is shipped to North Carolina by rail, and half by truck. Truck transportation is principally from North Carolina and adjacent states.

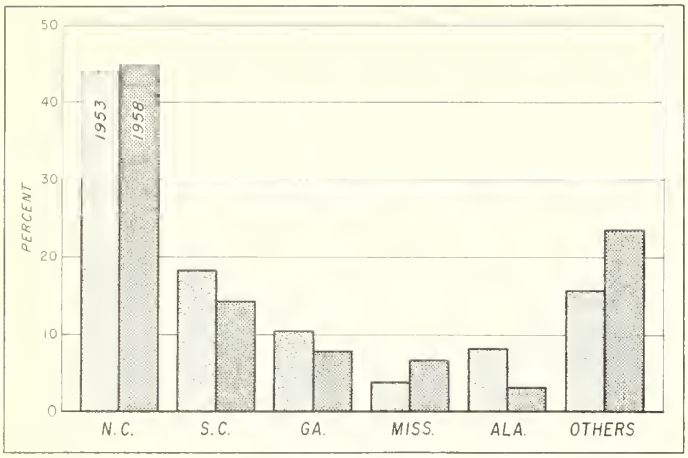


Figure 63.—Source of lumber used in North Carolina furniture plants.

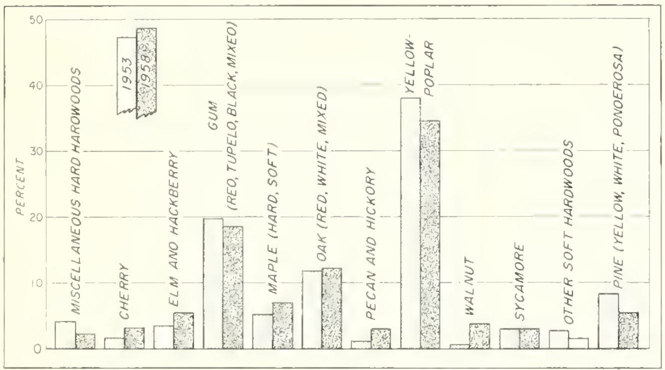


Figure 64. — Lumber used in North Carolina furniture plants by species.

Service Activities

Service activities by the Division have been characterized by increased technical assistance to industry and an extensive information-education program.

Considerable technical aid has been given in developing a method of making charcoal from fine residue by continuous carbonization.

During the past year, Division personnel have closely followed the development of a sparse-tooth saw to produce coarse sawdust for pulp, and have cooperated with industry in evaluating this method of sawing.

A market survey is currently under way to determine the possibility of additional hardwood industries in Georgia.

Detailed inspections of dry kilns and drying schedules were made at a western North Carolina dimension plant and at a Georgia veneer and plywood company. Recommendations based on these inspections should enable the plants involved to dry lumber faster and with less degrade. A number of air-seasoning yards were visited and suggested changes recommended to expedite drying and to eliminate blue stain.

In addition to these projects, Division personnel assisted in solving other wood utilization problems by numerous plant visits and through correspondence.

Papers were presented to technical groups covering a variety of subjects. Among these were discussions on sawing for grade, predrying research, moisture content of wood in homes, stabilizing wood, continuous carbonization of fine residue, current developments in seasoning wood and residue utilization.

Training schools were conducted to acquaint foresters with utilization problems. A number of sawmill clinics were held for mill owners and operators in north and south Georgia. Talks were presented to various civic organizations and to schools emphasizing the need for more efficient wood utilization.

RANGE AND WILDLIFE HABITAT

RANGE

Problems arising from attempts to integrate cattle and timber management are being explored on the Alapaha Experimental Range near Tifton, Georgia, and on the Caloosa Experimental Range near Fort Myers, Florida. On the Alapaha, in cooperation with the Georgia Coastal Plain Experiment Station and the Agricultural Research Service, cattle-forage responses are being compared to provide guides for utilizing available forage in slash-longleaf pine forests managed primarily for timber. On the Caloosa, studies of cattle stocking rates and utilization of pineland threeawn (wiregrass) will provide information for managers of cattle-timber enterprises in the cutover flatwoods of South Florida.

Methods of controlling gallberry—an undesirable invader of southern ranges—have been developed at the Alapaha, and J. B. Hilmon, on academic leave from the South Florida project, is studying the problem of saw-palmetto in his doctorate program at Duke University.

CATTLE INJURY TO PLANTED PINES

As the South moves ahead with its huge tree planting program, attention focuses naturally on all factors influencing ultimate timber yield. A prime factor in the flatwoods country is the cow. Timber growers and ranchers often ask, "What injury can I expect if I graze my new tree plantations with cattle at reasonable rates of stocking?" Crucial decisions hinge on knowing how soon the young stands can be safely grazed; whether tree damage can be mitigated by fertilization, feed supplementation, or special practices; and what the grazing impacts are on tree growth and quality after plantations reach sapling and pole size.

Although the Station's range research has not progressed to the point where type and degree of cattle injury can be equated with timber yield, some interim results are interesting. At Alapaha, injury to seedlings has varied from very little in open range plantings where cattle have access to ample amounts of burned range or improved pasture, to excessive where cattle were confined to small plantation pasture units. In most cases tree size, growth stage, and range management procedures apparently had something to do with the degree of cattle injury. Likewise, results on the Caloosa Range show that rate of stocking and age of rough are important factors influencing tree injuries.

Tree Injuries on Open Range and Pastures

In 1959, several hundred pine seedlings were planted in open range and large improved pastures at Alapaha to provide information on the effects of grazing where cattle had a variety of abundant forage. Prior to machine-planting, seedlings were dipped in ZAC (Zinc dithiocarbamate), a cattle repellent developed by the U. S. Fish and Wildlife Service. Undipped seedlings were also planted. Grazing pressure by cattle, with free access to 15 to 20 acres of native range and 0.6 acre of improved pasture per head from March 24 to October 1, caused light use of range forage and very heavy utilization of the more limited amounts of improved pasture.

Frequent observations during the spring and summer showed that injury to young pine seedlings increased rapidly during the period of new shoot development (fig. 65). By late April, 23 percent of the seedlings planted on native range had been injured; thereafter, the number of additional trees injured was more than offset by the number that had recovered from earlier injuries. In pasture plantings, 67 percent of the trees were injured during their first flush of growth (early May); by late summer about 80 percent showed injury. Death of trees planted on open range occurred mostly in June and July, and by October 1, 6 percent were dead. Seedlings planted in pastures suffered heavy losses from May through September, and 65 percent were dead by October 1 (fig. 66).

Because animal damage was almost entirely mechanical, there was no opportunity to evaluate the effect of ZAC on reduction of

needle browsing, and no definite benefits from ZAC were apparent in these trials (table 16). Primarily these 1959 plantings on lightly stocked range demonstrated the relatively low resistance of seedlings to mechanical injury in their first growing year.

Damage to South Florida Pines Under Several Rates of Cattle Stocking

A study of the kinds and degrees of injury to planted pine seedlings under controlled intensities of cattle stocking has been started on the Caloosa Experimental Range. In this study, pastures are stocked with cattle at low, medium, and high rates in season, based on three levels of pineland threeawn utilization: 30, 22, and 15 acres per cow per year.

In January 1959, seedlings of longleaf and South Florida and common slash pine were planted within each of the rated range units. In 6 of the 12 experimental units the range vegetation had been burned off about 60 days before planting; these units were designated 0-rough. Cattle were grazing these units at the time of tree planting. In the other 6 units —designated 1-year rough—range vegetation had been burned off about one year earlier. In accordance with usual grazing practices, cattle were not turned in to graze the 1-year rough until March, about 8 weeks after trees were planted. A fourth intensity of stocking (zero rate) was provided by fencing off newly planted trees against grazing in experimental units of both 0-rough and 1-year rough.

Grazing injury began almost immediately after planting on the 0-rough. In 9 days, 58 percent of the South Florida slash seedlings, 34 of the common slash, and about 4 percent

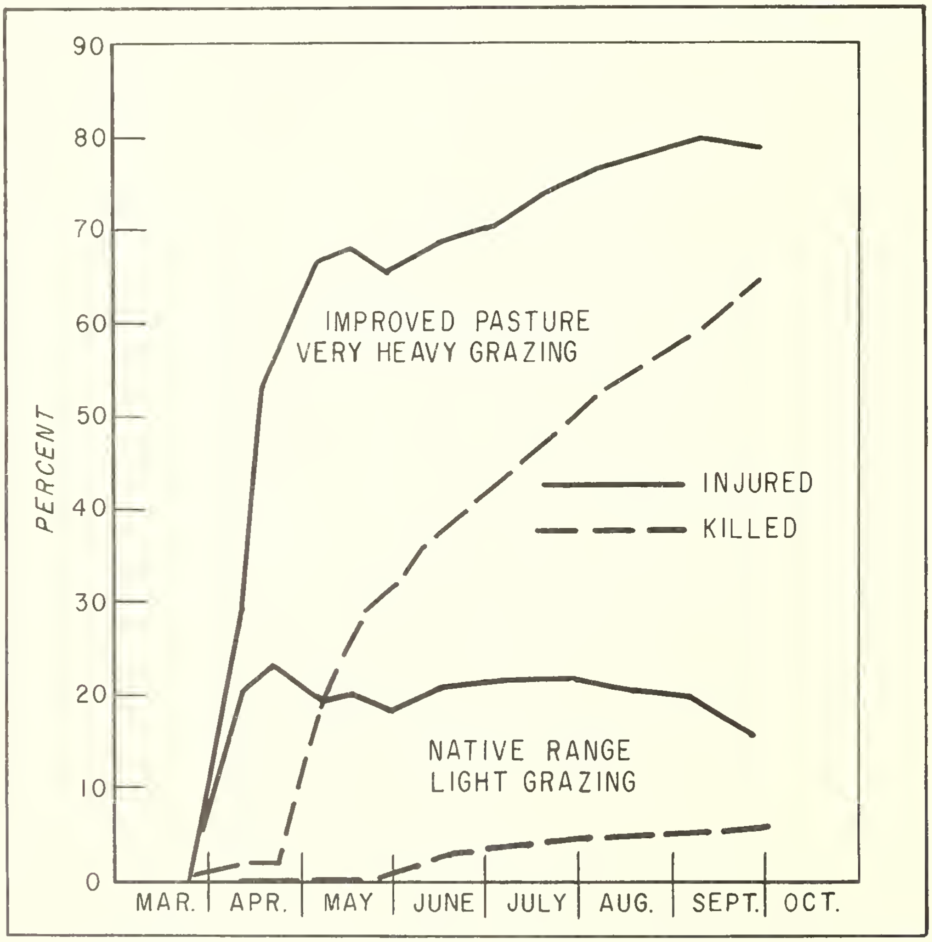


Figure 65.—Percentage of injured and killed trees on improved pasture and native range the first growing season after planting.

Figure 66.—Rubbing and bending of planted slash pine (*left*) caused breakage of the stem and often death of the young trees (*right*).

Table 16.—Spring-summer effects of cattle grazing slash pine seedlings planted on native range and improved pasture, 1959

Observation		Range plantings		Pasture plantings	
		Treated 1/	Untreated	Treated 1/	Untreated
		- - - - Percent of trees planted 2/ - - - -			
0	No grazing injury	89	86	22	23
1	Needles browsed $<$50%	0	0	0	0
2	Stem bruised	0	--	7	4
3	Needles browsed $>$50%	0	0	--	0
4	Stem trampled, not broken	3	3	2	2
5	$<$50% of lateral buds or branches damaged	0	0	0	0
6	$>$50% of lateral buds or branches damaged	0	0	0	0
7	Terminal buds grazed or broken	2	2	18	18
8	Stem broken	6	9	50	52
9	Seedling destroyed	6	6	64	65

1/ Bundle-dipped in ZAC (Zinc dithiocarbamate) prior to planting.

2/ Injury percents do not total 100; some trees suffered more than one kind of injury, and each instance of multiple injury was recorded.

of the longleaf showed severe grazing injury in one high rate pasture. This initial injury included needles almost completely browsed, terminal buds bitten off, and seedlings partially to completely pulled from the soil (fig. 67). Similar counts in a low rate pasture at this time showed that only 4 trees out of 150 had suffered moderate to severe grazing injury.

Three weeks after planting, a detailed check of all trees planted on 0-rough showed high percentages already injured in varying degrees in the units with high rate of stocking, but only a few trees had suffered under medium and low rates of cattle stocking (table 17).

Early injury in the high rate units was directly attributable to amount of available forage; i. e., concentrations of cattle and limited amounts of grass in these ranges induced injury by browsing and other disturbances to newly planted trees. In the medium and low rate pastures, there was sufficient forage to prevent this.

First-year data taken in late summer showed striking reductions in survival for the the three pine species subjected to high-rate stocking on 0-rough compared to survival under the other rates (fig. 68). There were no differences in survival attributable to rate where trees were planted on 1-year rough.

While data from this study provide leads on initial injury and the influence of rough age and rate of stocking on tree injury, the real answers can only come when ultimate timber yields are also considered. This means that experiments must carry trees to age 10 years or more so that growth and yield data from stands subject to grazing injury can be compared with expected yields where grazing injury is not a factor.

Table 17.—Trees injured by grazing, 3 weeks after being planted on fresh burn

Cattle stocking	Longleaf	South Florida slash	Common slash
	- - - -	Percent	- - - -
High	31	68	47
Medium	13	16	19
Low	2	2	5

Figure 67.—Severe grazing injury to pine seedlings began soon after planting in freshly burned range. This injury included needles and terminal buds browsed and seedlings removed completely from the soil.

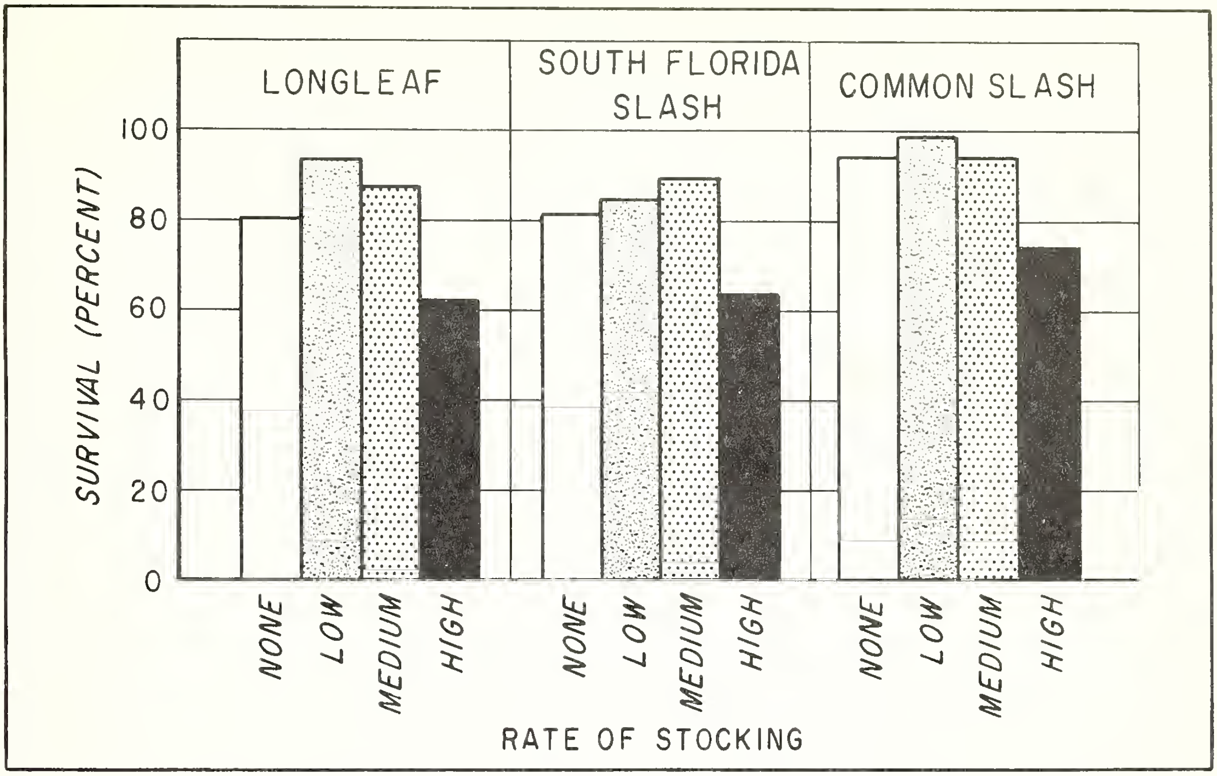


Figure 68.—First-year survival of planted longleaf, South Florida, and common slash pine under four rates of cattle stocking.

WILDLIFE HABITAT

Wildlife habitat research has moved ahead considerably since its inception at the Station in 1958 and several important studies are under way. With few exceptions, the work is developing cooperatively with other agencies, reflecting the widespread demand for managing game resources as an integral part of forest holdings.

Among activities is an appraisal, now getting under way at the Lake City Center, of the effect of site preparation for tree planting on game food and cover plants in the longleaf-slash pine flatwoods. Hunting compartment statistics are being analyzed jointly with the North Carolina Game Division in an effort to assess factors that contribute to deer kill and hunter success. Methods of sampling the relative carrying capacities of deer range are being developed and tested for use in the Timber Survey. An exploratory study of plant succession and soil-water relations on deer range recovering from severe overuse is being planned jointly with the North Carolina National Forests. The latter is a first step toward studying multiple-use aspects of range recovery affecting timber, game, and other resources.

Timber Cutting Affects Deer Browse and Tree Reproduction

During the year, the Asheville Research Center contributed importantly to the Station's developing program in game habitat by reappraising the results of an administrative-type cutting intensity study installed on the Pisgah National Forest in 1949. On three 70-acre compartments, a seed tree cut (all woody plants cut), a modified selection cut, and a standard sawtimber sale cut were made in an area supporting a high deer population. Counts taken in 1951 had indicated a clear relation between cutting intensity and numbers of regenerating stems, and also suggested some large but probably unimportant differences in regrowth with ample browse and tree regeneration in all compartments.

Figure 69.—Seed tree cutting in fairly large blocks may permit satisfactory stand regeneration and provide abundant deer food where browsing pressure is heavy.

Ten years after treatment (1959) comparative stem counts showed substantially more regeneration of commercially desirable species of satisfactory origin in the seed tree compartment than on the area receiving a conventional timber sale cut (490 vs. 149 stems per acre). Also, browse supplies, though not measured, obviously were more abundant on the seed tree cut (fig. 69). Such differences favoring seed tree cutting were apparently due to deer browsing activity, since the earlier count had showed abundant reproduction in both compartments and since the understory in the standard sale area is now typically overbrowsed, with only moderately heavy use apparent in the seed tree cut.

Followup study to determine the effect of a cleaning on the production of resurgent browse, and to improve composition and growth in crop trees is planned. The work will be done by the Center and State Game Division in treated and untreated plots in the original seed tree area. Measurements to compare tree growth, browse production, and deer activity will also be made.

Studies With Penned Deer

First work to determine carrying capacity has been started in an 800-acre deer enclosure located on the Marine Corps Supply Base near Albany in the upper coastal plain in Georgia. This unit will be stocked by the Georgia Game Division with coastal deer. Once established, the over-wintering stocking will be maintained at 30 animals and surpluses will be removed annually by hunting. Pre- and post-season deer drives will provide estimates of herd size. Begun and conducted by the Georgia Game Commission, this study's major emphasis will be the determination of hunting pressure, success values, and animal performance as related to cover change and browsing pressure.

The Albany enclosure typifies recently abandoned old field areas in the upper coastal plain, and probably will produce large quantities of forage for several years. Forage production is expected to reach a high during the 10-year study period, and it is hoped that an over-wintering herd of 30 animals in the 800-

Figure 70.—The Broad Run area was recently opened to hunting by construction of a 9½-mile access road. A continuing study of unrestricted hunting pressure will yield important data on the recreational use of newly accessible areas.

acre tract may approach the carrying capacity at the peak in forage production.

Station participation involves sampling for trends in vegetation as modified by deer browsing activity. A method of point sampling along permanent transects is being used to sample the woody understory. Initial measurements are completed, and exclosures are being constructed to exclude the herd from half the transects. Remeasurement will be carried out bi-annually for the duration of the study.

This study affords excellent opportunities to appraise current deer census techniques and to develop improved inventory methods. Accordingly, the Fish and Wildlife Service has superimposed a census methods study to test for precision and reliability in estimating herd size and distribution.

Appraisal of Current Forest-Wildlife Management Practices

On the Broad Run Area of the Jefferson National Forest, an evaluation of forest-wildlife management systems employed on several large compartments (1500 to 2000 acres) is progressing very well under the leadership of the Virginia Cooperative Wildlife Research Unit.

Area treatments are being evaluated mainly by population response of the principal game animals. Deer herd dynamics have been emphasized in first appraisal efforts, and considerable attention has been given to associated sampling problems.

In addition to appraisals of management systems, the Broad Run compartments provide case histories on hunting pressure and success (fig. 70). Because the area was virtually inaccessible, tabulations on unrestricted hunting pressure will yield information on hunting recreation build-ups in newly accessible and intensively managed forests. Annual inventories, to determine pressure and success values, have been conducted jointly by the Wildlife Research Unit and the Range-Wildlife Division.

Hunting pressure increased approximately 600 percent between the first and second year (250 to about 1435 man-hours), but dropped about 45 percent between the second and third year (down to 775). A gradual increase in pressure is expected, however, during the next few years, corresponding to an observed increase in game supplies, especially deer.

FOREST INSECTS

During most of the past decade our entomologists were beset with epidemics of the tree-killing bark beetles which destroyed many millions of board feet of pine throughout the whole Southeast. As attacks appeared to diminish, there was hope that we could settle down to basic research on bark beetles to determine the reasons for epidemics and to develop sound methods of control. With the decline, however, new problems arose to take the place of the old. Thus, at the end of the decade there are serious outbreaks of pine sawflies throughout the Station territory, and the elm spanworm, the forest tent caterpillar, the fall cankerworm, the oak pit-making scale, the pine needle miner, the pine leaf chafer, and the balsam woolly aphid are active in various sections of the territory. Some of these may require short-term studies; others may require lengthy ones.

As a result of research on the balsam woolly aphid our attention has been focused more rapidly on biological control. Releases of imported predators have been made, and more are anticipated. *Bacillus thuringiensis,* a microbial pesticide, is being explored and looks promising against the tip moth. If we study defoliators more intensively in the near future, we may get into the study of viruses, another promising aspect of biological control.

The ultimate in sound, effective control measures can be developed only through basic research on the organism and on the control techniques involved. We are making an effort toward that goal. Insect research at Lake City and Macon is concentrated largely on one problem and one or two insects at each location. This year a laboratory facility was set up at Bent Creek Experimental Forest and efforts were made toward adequately equipping it (fig. 71).

Balsam Woolly Aphid

Fraser fir on Mt. Mitchell are dying at an accelerated rate from attack by the balsam woolly aphid, *Chermes piceae.* On the basis of various records and studies on rate of mortality, estimates were made on the probable losses occurring around Mt. Mitchell in the years preceding detection of the outbreak in 1957. The following figures show losses of the past five years:

Year	*Number of trees killed*
1955	700
1956	2,000
1957	5,000
1958	11,000
1959	21,000

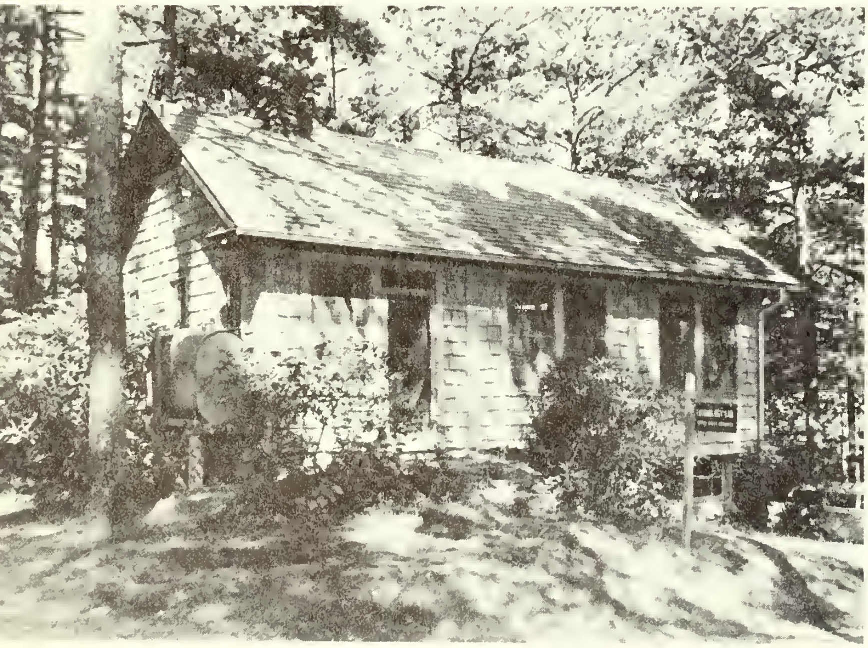


Figure 71. — One of the insect laboratory buildings at Bent Creek Experimental Forest. The interior has been improved for office and laboratory use. There are two insectaries available nearby.

Aerial and ground surveys of all remaining Fraser fir stands in the southern Appalachians failed to reveal the occurrence of the aphid in any new locations.

A seasonal biology study on Mt. Mitchell showed that the occurrence of three generations per year was common and that a few aphids passed through four generations. This fact, plus the extremely high susceptibility of Fraser fir to aphid attack, may explain the extensive and rapid killing which is taking place. Most of the trees have died after only two or three years of stem attack by the aphid.

The pilot test to determine the effectiveness and cost of control of spraying roadside strips on Mt. Mitchell and the Blue Ridge Parkway began on April 16 and terminated on May 2. During this period 18,000 gallons of a soluble oil spray were applied to about 13 acres of roadside strip in 63 spray hours (fig. 72). Roughly 12,600 trees were treated, and the average amount of spray applied per tree was about 1½ gallons.

Biological control appears to offer a promising method of reducing balsam woolly aphid populations in this relatively small outbreak area where stand conditions, terrain, and costs permit only restricted use of insecticides. Biological control measures were started in June with the release of two species of predators collected in Germany through the cooperation of the Commonwealth Institute of Biological Control, Canada Department of Agriculture, and the Agricultural Research Service of the U. S. Department of Agriculture. A total of 619 *Laricobius erichsonii* beetles and about 10,000 predaceous flies, *Aphidoletes thompsoni*, were released in the vicinity of Mt. Mitchell. Before these almost microscopic flies could be released, it was necessary to rear them to the adult stage under strictly controlled conditions and to isolate and destroy a hyperparasite (fig. 73). Over 3,000 of these tiny parasitic flies were collected and destroyed before the *Aphidoletes* could be released in the field (fig. 74).

Control of the aphid through cutting practices was tried on an experimental basis. Some trees were girdled and some were felled in the fall of the year after most of the aphids had entered dormancy. This was done to dry out the tree and hence cause the death of the insects before spring when they would reproduce. The feasibility of using the tops of felled trees for Christmas trees was explored to offset the cost of this operation. Girdling and felling as a control of the aphid did not prove 100-percent effective because of inadequate drying. However, the population of aphids was greatly reduced.

The aphids were able to move from tops cut for Christmas trees when they were taken into the laboratory the second week of December. This study showed that aphid-infested tops could serve as a source of infestation to uninfested areas.

Figure 72.—Spraying roadside strips of Fraser fir on Mt. Mitchell, North Carolina, to control the balsam woolly aphid.

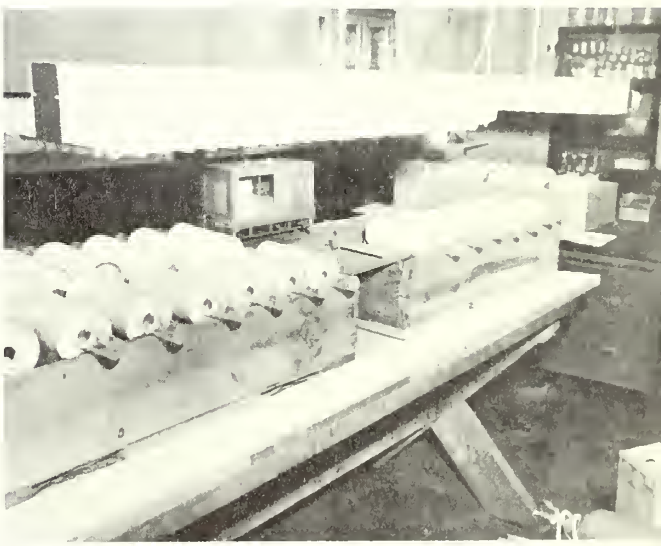


Figure 73.—Predator of the balsam woolly aphid being reared under rigidly controlled conditions.

Figure 74.—Adults of the predator, *Aphidoletes thompsoni,* being released on an aphid-infested Fraser fir. The cage is removed after the flies lay their eggs and die.

Elm Spanworm

The extent of noticeable defoliation by the elm spanworm, *Ennomos subsignarius,* increased 290,000 acres over that of 1958. Although a total of 860,000 acres of hardwood forest in the mountains of Georgia, Tennessee, and North Carolina were attacked, the intensity of the defoliation was considerably reduced over former years. Unlike previous years, no completely defoliated areas were observed. Indications are that future defoliation will become less severe. However, the adverse effects of repeated defoliation will manifest themselves for several years in reduced tree vigor, loss of growth, and tree mortality (fig. 75).

A study of parasites of the spanworm showed that neither the eggs nor the early instar larvae were attacked. Late instar larvae and pupae were attacked by both Diptera and Hymenoptera; however, control by these parasites was insufficient to affect seriously the spanworm population. Several parasites not previously recorded as attacking the spanworm were recovered.

Because microbial pesticides were reported to control some Lepidoptera effectively, an exploratory study was made to determine the effect of *Bacillus thuringiensis* on the spanworm. Trees were sprayed at various elevations with three different concentrations of the *Bacillus* in water. Examination of larval mortality for several weeks following spraying showed that, under the conditions of the test, the *Bacillus* was only partially effective as a control agent.

Figure 75.—Tree mortality caused by elm spanworm defoliation in Georgia.

Pine Sawflies

Pine sawflies continued to be a problem throughout the Southeast, with populations increasing in some areas and declining in others. In the Piedmont Plateau area of Virginia and North Carolina a marked increase in intensity of feeding by the Virginia pine sawfly, *Neodiprion pratti pratti,* occurred on shortleaf and Virginia pine on over 2 million acres(fig. 76). This is a several-fold increase over the area defoliated in 1958. In Georgia an area of about 500 acres of slash pine was defoliated in the east-central part of the State for the first time. In contrast, sawfly defoliation which occurred on 300,000 acres of loblolly pine in west-central Florida in 1958 drastically declined in 1959. This decline was due principally to natural control factors.

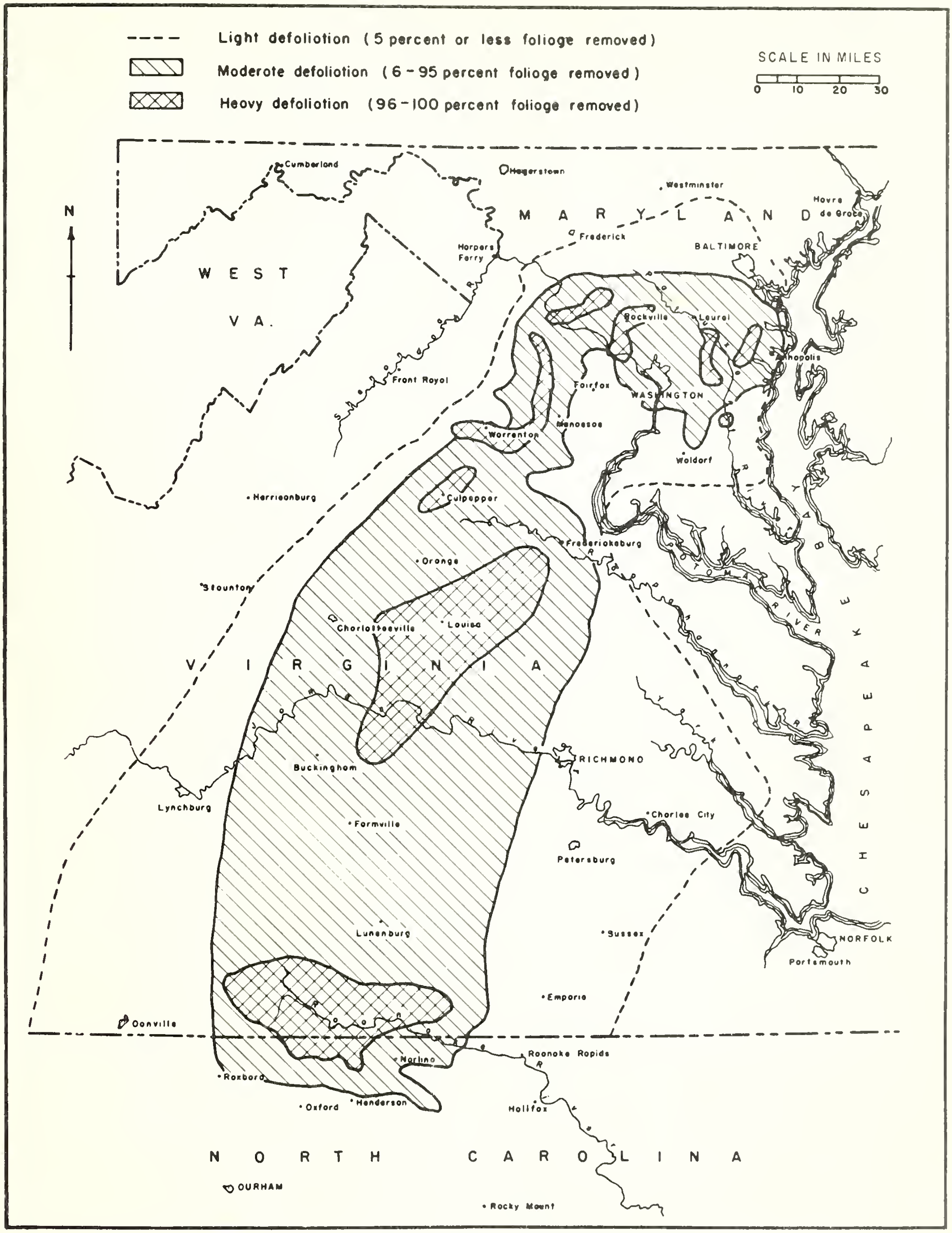


Figure 76.—Area in Virginia and North Carolina defoliated by the Virginia pine sawfly.

Nantucket Pine Moth

During the past year work has continued on the biology of the Nantucket pine moth, *Rhyacionia frustrana*. In particular the activity of the larval stage and egg incubation period have been followed very closely on trees in the field. Previous work indicated that the larvae spent their early life on the outside of the tips and fed on the needles and succulent surface tissue of the developing shoots. This prompted work to follow larval development and activity. Several interesting observations were made. Egg incubation in the spring extended over a period of approximately two weeks. Early larval feeding was external, and it was not unusual to find first instar larvae moving about freely on the developing shoots. Head capsule measurements in the laboratory and observations in the field indicated that internal feeding by the larvae occurs after the third instar. During these first three instars larvae were found to construct webs at different locations on the shoots, but in most cases these were temporary and third instar larvae could occasionally be found crawling about the tips.

A study was made to determine the parasites and predators which attack the Nantucket pine moth in central Georgia and their relative importance. Possibly the most important parasite collected is a small hymenopterous egg parasite, *Trichogramma minutum* Riley; in field collections of tip moth eggs, over 50 percent were found to be parasitized by it. A group of closely related predators of the genus *Phyllobaenus* spp. were the only insect predators found attacking the tip moth. Their great abundance and their ability to devour more than one host undoubtedly make them an important biological control agent.

Exploratory tests of the microbial pesticide, *Bacillus thuringiensis*, showed a high degree of control of early instar tip moth larvae and less control of older larvae.

Insects Destructive to Flowers, Cones, and Seeds of Pine

Studies have been continued at Lake City, Florida, on the insects destructive to flowers, cones, and seeds of slash pine. Emphasis has been given to the biology of the two most damaging species, *Dioryctria abietella* and *D. amatella*, particularly to round out information on their life cycle and behavior patterns (fig. 77).

Research on other associated species is also in progress. Two species of moths which directly injure the seed of pine are under study —*Laspeyresia ingens* and a new species, *L. anaranjada*, collected at Lake City and recently described by Miller in *The Florida Entomologist*. The larvae of both species mine the seed. Several other species of insects are being studied to determine the real importance of their damage to the seed crop. Tests to evaluate schedules and the effect of various formulations of insecticides on *Dioryctria* spp. and *Laspeyresia* spp. have been continued (fig. 78).

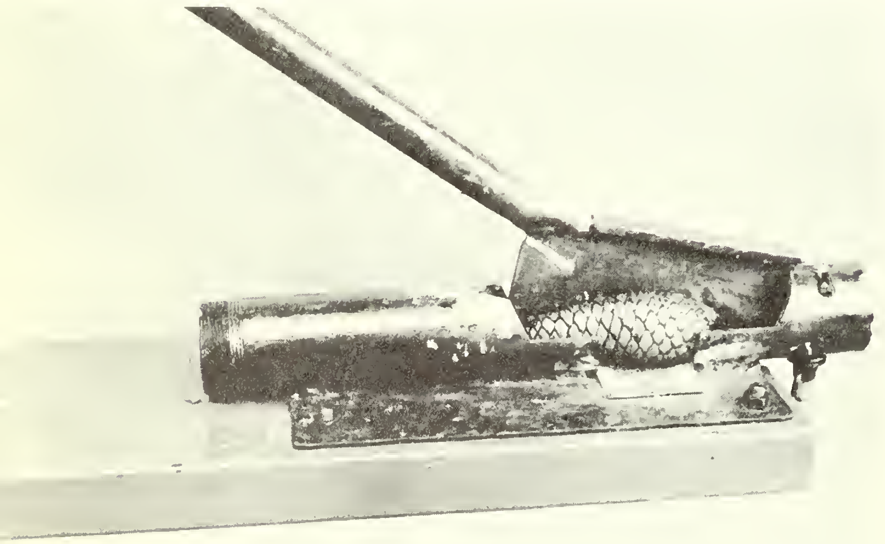


Figure 77. — A cutting tool developed at Lake City Research Center enables entomologists to open cones easily and facilitates study of the biology of the insects and the damage they cause.

Figure 78.—During 1959 a field study was conducted at the Lake City Research Center to determine the effectiveness of different spray schedules to control *Dioryctria* spp. coneworms and *Laspeyresia* spp. seedworms attacking slash pine cones. The 0.5-percent BHC water emulsion is being applied to the 45-foot pines by means of a hydraulic sprayer.

Southern Pine Beetle

During the summer about 800 pines were killed by the southern pine beetle, *Dendroctonus frontalis,* on the General Pickens District of the Sumter National Forest in South Carolina. Control measures were quickly put into operation to prevent further spread. All land-managing agencies involved in the latest serious epidemic were warned to check their stands carefully. Aerial surveys of these stands revealed no new outbreaks.

On the basis of 1958 findings that 95 to 100 percent of the hibernating stages were killed the previous winter by subzero temperatures, it was predicted that southern pine beetle populations would likely be at a very low level in 1959. These predictions were correct, except for the small flareup described above.

Surveys in the spring in eastern North Carolina failed to reveal any new beetle outbreaks. A fall survey of the same area uncovered a small population buildup in several hundred infested trees.

Limited exploratory studies and observations were made to determine the nutritional and environmental requirements of the southern pine beetle. This was done in the hope of developing a method for rearing quantities of beetles for biological studies and for determining conditions under which outbreaks occur.

Black Turpentine Beetle

Attacks by the black turpentine beetle, *Dendroctonus terebrans,* in living trees were uncommon this year. Some buildup of beetle populations occurred in South Carolina, Georgia, and Virginia in local areas where logging occurred or where trees were weakened by lightning. In Virginia some control work was done by spraying stumps and the bases of injured trees with 1-percent benzene hexachloride in fuel oil. In no case did activity extend into adjoining uninjured healthy trees.

Ips Engraver Beetles

An operational survey covering over 6 million acres was made in eastern Georgia and southeastern South Carolina during the summer in response to reports of abnormal losses caused by *Ips.* On 3 million acres of pine type, nearly 160,000 dying trees were observed. *Ips* beetles were the principal cause of most mortality. This survey, as well as other observations, demonstrated that *Ips* losses were comparatively low during 1959.

Pine Root Aphids

White pine blight, which is characterized by dieback, shortening, and chlorosis of needles, or a combination of these symptoms, has been recognized by pathologists for many years in eastern United States. Its cause, however, remains to be determined. Some believe that it is a disease or a complex of diseases. Because aphids are commonly found feeding on the roots of white pine, there is a theory that they may contribute to the blight.

A study was started in cooperation with the Division of Forest Disease Research to determine whether aphids might be involved. Insecticides were applied to the root area and the foliage of diseased white pine in eastern Tennessee in order to control any insects which might be present. If the trees recover from the disease symptoms, a basis will be established for further research into the role of insects in causing the blight.

Collections of aphids have been made from roots of white pine and their occurrence has been observed. The species involved are unknown because adult winged forms, upon which classification is based, had never been collected previously. By making periodic collections of immature aphids this year and holding them in the laboratory for continued development, winged adults have been obtained. There appear to be two different species and sample specimens have been forwarded to specialists for identification.

WATERSHED MANAGEMENT

During the year, progress was made in basic studies of water disposal processes of forest lands at both the Coweeta Hydrologic Laboratory in the mountains of western North Carolina and at the Union Research Center in the Piedmont of South Carolina.

At Coweeta an effective start was made on a study of the hydrology and dynamics of soil moisture storage and movement on steep mountain slopes. This research utilizes a new soil model and other apparatus, and essentially involves a critical re-examination of our concepts as to the source of base flows which sustain small mountain streams during dry periods.

In a current Coweeta study, a new look is being taken at conventional hydrologic concepts and their applicability to analyses of runoff data from small mountain streams. Another recent study reports on the influence of mountain topography on solar energy relationships affecting evapotranspiration loss. These studies were thesis problems which Alden Hibbert and Lloyd Swift, Jr., worked on in fulfillment of requirements for their Masters' degrees.

John Hewlett continued work toward his doctorate at Duke University, majoring in studies of moisture tension relationships in forest trees as possible indicators of water-use requirements. This marks first Station efforts toward basic study of some of the plant physiological factors affecting water losses, particularly the internal water balance mechanisms which may control water use demand. Hewlett has served as Acting Center Leader at Coweeta, following transfer in June of Donald Whelan to the U. S. Southeast River Basins Study Commission in Atlanta, and he has continued to give general guidance on technical phases of the Coweeta work since his return to Duke in September.

New work at Union by James Douglass features studies to develop more efficient sampling techniques for quantitative measurement of soil moisture in forest stands.

SOIL MOISTURE STUDIES HOLD MANY ANSWERS IN WATERSHED MANAGEMENT RESEARCH

For many years most watershed management research has featured measurement of runoff response from small drainage units in testing effects of watershed treatment. Generally, the aim has been to evaluate the effects of plant cover and land management practices on water yield, on sediment production, or on evapotranspiration loss; studies of small watersheds usually afford the most direct gross measure. More useful evaluations, however, could probably be made if we knew more about the water demands of various types of watershed cover and how they affect the water regime of soils. Thus, soil moisture studies should assume much greater importance in water management research because they not only can supply needed answers but will enable better interpretations of watershed processes and why they operate the way they do.

Soil moisture studies already have played an important role in research activities both at Union and Coweeta. At the former, Colman electrical-resistance units were utilized in a 7-year study of the soil moisture regime of some typical Piedmont cover types. This investigation compared the influence of pine, pine-hardwood, native broomsedge grass, and no cover (bare soil) on moisture depletion, rainfall recharge, and storage capacity relations for soil profiles to a depth of 66 inches.

In summary, the Union study showed that moisture recharge and depletion are cyclic, recurring in about the same pattern each year with only minor variations due to climate. However, there was no measurable difference in the rates at which soil moisture was depleted under several forest cover types; i. e.,

a young loblolly pine plantation, older shortleaf pine, or mixed pine-hardwood stands.

As between tree and grass cover, the rate of moisture loss varied by depth. Moisture depletion under the broomsedge cover was confined almost exclusively to the surface 30 inches of soil; under deeper-rooted forest vegetation, water was withdrawn to depths of 66 inches. Figure 79 compares the moisture levels observed under pine and broomsedge during 1952. It shows that by November—marking the end of growing-season moisture depletion and the beginning of the soil moisture recharge period—the aggregate difference in moisture levels amounted to more than 6½ inches of water.

Figure 80 compares depletion rates from a 66-inch profile under pine, broomsedge, and barren plots. The evaporation rate (represented by the depletion curve for bare soil) was considerably less than the rate of loss (evapotranspiration) from vegetated plots. Presumably, differences in rooting habits account for the greater moisture depletion on the pine plot. Broomsedge roots, restricted mostly to the upper 30 inches, come in contact with less soil moisture and consequently deplete water at a slower rate than pine.

These findings suggest that trees and other deep-rooted vegetation use much moisture and thereby create more space for intake and storage of winter rains, with consequent reduction in damaging stormflows. Also, it may logically be surmised that water yield from shallow-rooted grass cover exceeds that from the deeper-rooted pine, but at this stage no easy generalizations are possible. Whatever the water demands of various types of plant cover, this in no sense means keeping soils barren as a method of management nor dispensing with forest vegetation as an efficient protector and regulator of soils and water supplies.

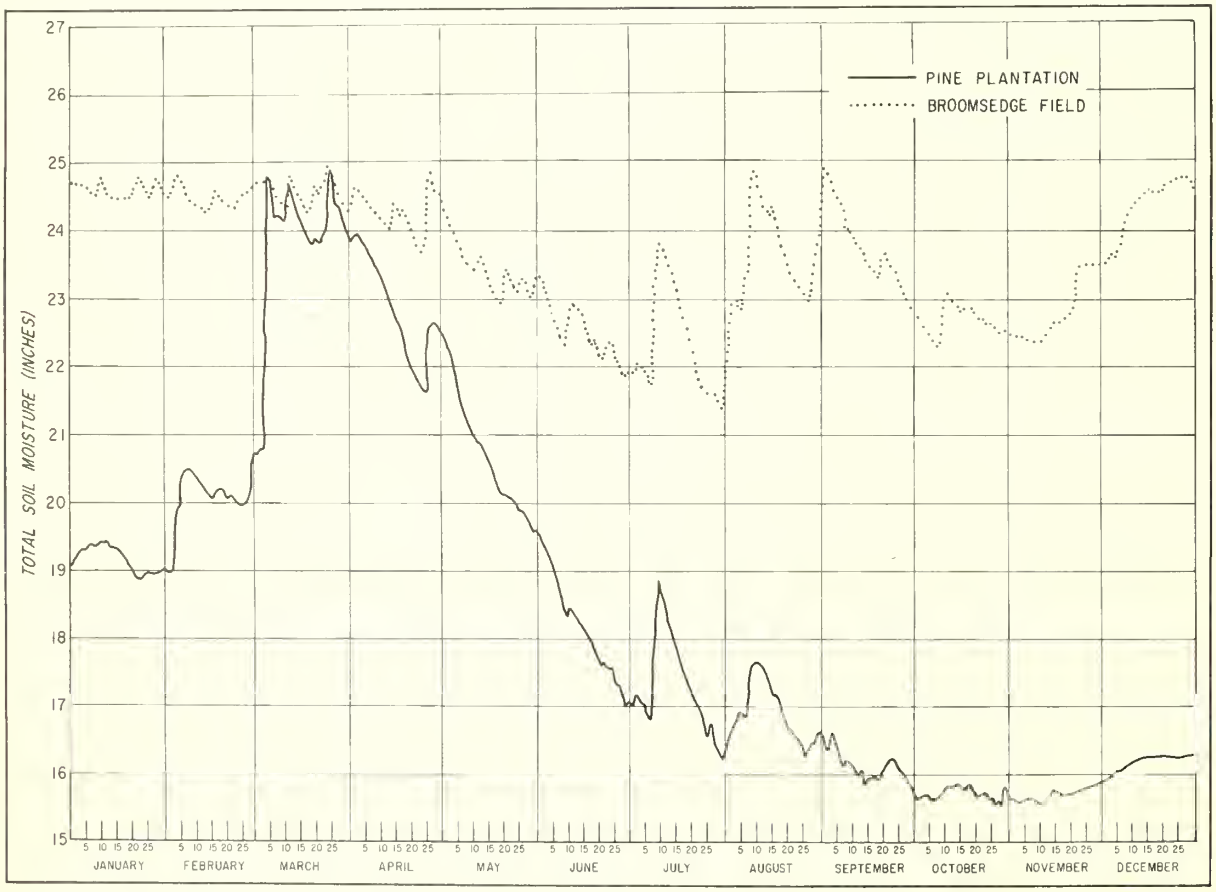


Figure 79.—Soil moisture regime in a pine plantation and native grass field to a depth of 66 inches (1952).

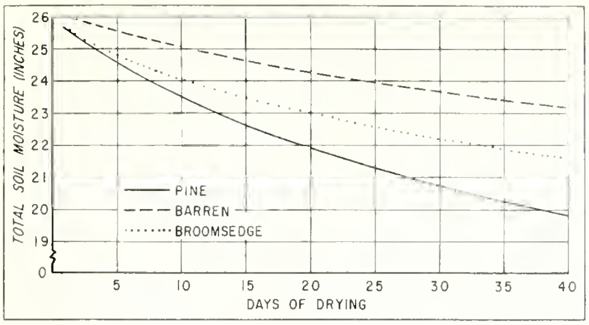


Figure 80.—Soil moisture depletion of the 0 to 66-inch zone of a pine plantation, broomsedge field, and barren plot.

Thinning Studies

Thinning timber stands offers one means of increasing streamflow, although it will take much basic and applied research to document the possibilities and enable reliable predictions of treatment response. At Union, a recent study was made of the effect of thinning a young loblolly pine plantation on soil moisture trends. Although there were some limitations in measurement method, definite dissimilarities were observed in depletion and storage trends under thinned and unthinned stands.

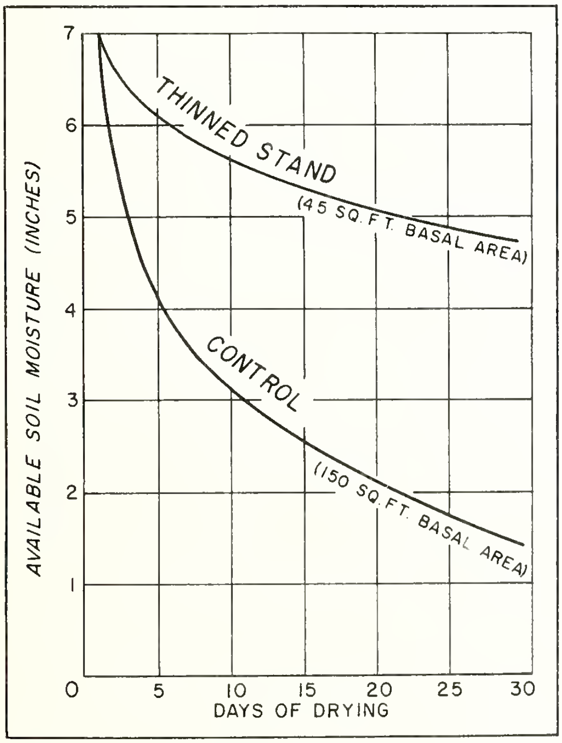


Figure 81.—Soil moisture depletion to a depth of 66 inches under thinned and unthinned loblolly pine stands.

Figure 81 compares soil moisture for the two levels of tree stocking and shows that the unthinned stand, with 150 square feet of basal area, used about 3 inches more water than the heavily thinned stand with a basal area of 45 square feet per acre. Although the difference in these preliminary observations may not seem particularly impressive, it suggests that commercial thinnings can substantially reduce evapotranspiration loss and thus may change water storage and yield relationships appreciably.

There were marked differences in distribution of moisture in the heavily thinned stand. For example, at the end of the growing season, the available storage space for winter rains in the upper 48 inches of soil at a point midway between trees (spaced 20 x 20) was about 4.4 inches, or little more than half that available directly beneath the trees (fig. 82). In contrast, the available storage space as gaged by moisture measurements was greater and was quite uniformly distributed between trees spaced 6 x 6 in the unthinned stand.

These findings, though exploratory, have important implications to watershed managers who must rely heavily on manipulation of cover, such as tree thinnings, to increase or decrease streamflow. Some well-known

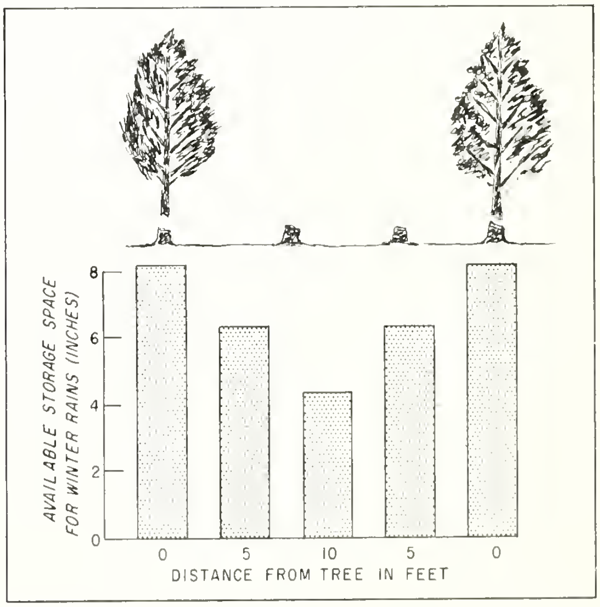


Figure 82.—Distribution of water storage capacity in a thinned loblolly pine plantation (upper 4 feet of soil) at end of the first growing season.

studies at Coweeta have shown conclusively that under conditions there, very substantial increases in regulated flows (up to 17 inches annually) can be obtained by cutting all forest vegetation, and that while water yields decline as watershed cover grows back, the increases persist in some degree many years after a single cutting operation. Naturally, much interest centers on whether changing the cover type as an adjunct to cutting itself will appreciably affect water yields.

Type Conversion Studies at Coweeta

An important major study at Coweeta, started in 1955, will compare the long-term water yield responses from a series of calibrated watershed units representing native hardwood forest, white pine on north and south aspects, a perennial grass, and low shrub cover. Conversion of a 22-acre unit from high forest to grass was accomplished during the past year (fig. 83). Kentucky 31 fescue was hand seeded on the steep slopes after a heavy application of 2-12-12 fertilizer and lime and a later top dressing of ammonium nitrate. An excellent grass cover was quickly established with minimum disturbance to soil and little apparent effect thus far on streamflow (fig. 84). This expensive treatment can afford only bench mark values of water yield changes after conversion to shallow-rooted grass cover; treatment will doubtless be difficult to maintain. Nevertheless, it is one key research approach to the whole problem.

It would greatly strengthen the Coweeta "type conversion" study to know something at this stage about soil moisture depletion trends under hardwood forest and grass and about the rooting habits, internal water economy, and other attributes of these cover types. Thus far, an exploratory Coweeta plot study of soil moisture regimes under hardwoods and grass shows little difference in moisture losses from the two covers. During winter and early spring, the mean daily loss in soil moisture from grass cover slightly exceeded that from hardwood forest, but during

Figure 83. — Watershed at the Coweeta Hydrologic Laboratory after conversion from mountain hardwood high forest to a fescue grass cover.

Figure 84.—A luxurious stand of Kentucky 31 fescue was established on this Coweeta watershed in a single growing season. The purpose was to ascertain whether conversion to a grass cover will increase water yield.

the summer the daily loss from hardwoods was greatest (fig. 85). These are preliminary results and should not be interpreted as meaning that such diverse types of cover as hardwoods and grass make the same water demands. These first observations, however, point to some interesting seasonal relationships which merit followup study.

Techniques of Measuring Soil Moisture

Although soil moisture studies afford one of the more fruitful approaches in water management research, they have been badly handicapped by lack of efficient measurement

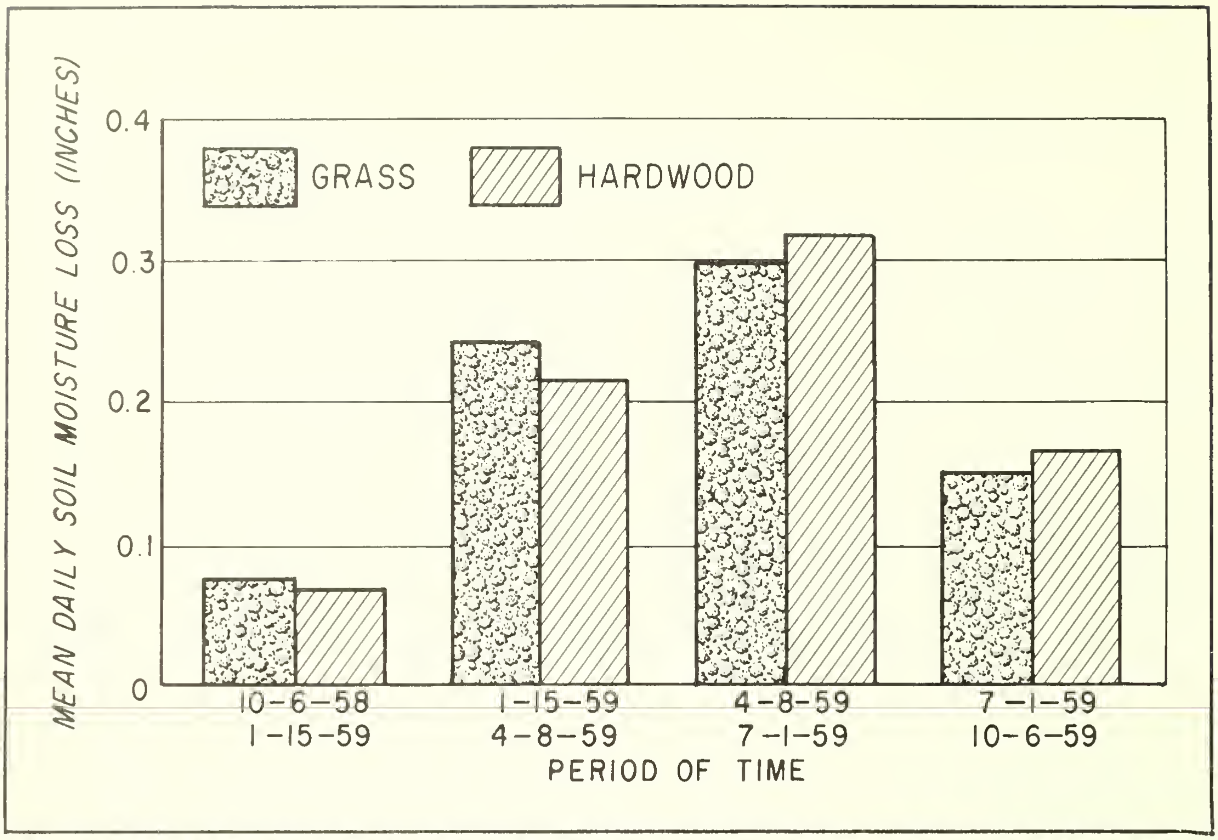


Figure 85.—At Coweeta, moisture losses from grass cover were higher in winter and lower during the summer than losses from a nearby hardwood cover.

techniques. Consequently, much of the work to date at Coweeta and Union has been devoted to studies to develop better and more reliable ways and means of measuring soil moisture. A publication describing a methed of calculating precision of estimates of soil moisture volumes will be released shortly. It suggests techniques for substantially increasing experimental precision. Correlation between bulk density of the soil and percent moisture by weight was found to be high on samples taken close together (r= —0.76). Thus, to take advantage of covariance, the authors propose use of sample clusters and offer a method for calculating the error of moisture estimates. At Coweeta, accounting for covariance reduced the number of samples required to estimate moisture at a given level of precision by as much as 75 percent (table 18).

A new neutron meter utilizing a radioactive moisture probe is proving accurate and reasonably reliable at Coweeta and Union and opens up exciting new possibilities in moisture investigations (fig. 86). A chief advantage is that remeasurement of the same soil mass is possible, and direct measurement of moisture volumes can be obtained rapidly. Replication is feasible and studies can be established with sound statistical planning. At Union, investigations are under way to determine field experimental design requirements of the method, precision of moisture estimates, and sample numbers required for specified confidence levels. Guidelines for more efficient use of the equipment will be developed.

The effective depth of rooting of pine is also being studied by the nuclear method. Studies which measure moisture to 6 and 8 feet may not sample water withdrawal effects on the whole soil profile because some roots may penetrate considerably below this level. Some years of study may be required to learn what the rooting-depth limits are, particularly since it may be only during dry years that vegetation exerts strong draft on moisture deep within the soil.

Table 18.—Number of Coweeta sample clusters required to hold expected standard error of moisture estimates to 1 percent by volume

Soil depth (inches)	Without accounting for covariance	Accounting for covariance (r = - 0.76)
	Number	Number
0 - 6	36	9
6 - 12	30	7
12 - 24	27	7
24 - 36	26	9
36 - 48	27	10
48 - 60	28	11
60 - 72	28	12
72 - 84	25	11

Applicability of the method for studying moisture in thinned timber stands and the vital problem of accounting for rainfall recharge through moisture measurements are also under study.

The future in soil moisture research seems highly promising. Once problems of measurement technique are solved, answers concerning storage capacity of soils, moisture recharge characteristics, comparative water use of plant cover types, and other related problems can be answered.

Basic relationships, ascertained through study of soil moisture regimes and substantiated in watershed tests, should provide more valuable and useful data than have previously been available. Moreover, the watershed manager, fortified with such findings, will be better prepared for sound management decisions in altering forest cover to meet water requirements.

Figure 86.—The neutron method holds promise as a reliable and accurate method of determining the volume of moisture held by the soil. It is currently in use in the Piedmont to measure moisture content of soils to depths of 16 feet.

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by
MEMBERS OF THE STAFF, INCLUDING COOPERATORS
Calendar Year 1959

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(Stronger acid, larger bark hack, and 2-quart cups particularly suited to intensive work.)

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KNOW YOUR FOREST INSECTS. Forest Farmer 19(3): 6-7. illus. (A key to common forest insects of the South based on damage characteristics, and meant to supplement the descriptive tables in the Forest Farmer Manual.)

Evans, T. C.
FIELD TECHNIQUE FOR EVALUATING THE SUCCESS OF ESTABLISHMENT. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 161-167. (Discussion of survey objectives, population characteristics, sampling units, and design with respect to direct seeding.)

Evans, T. C.
GENERAL APPRAISAL OF STATISTICAL PROBLEMS AND NEED. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 146-151. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta. (Discussion of sampling methods, sampling units, and field plot experiments as related to understory vegetation.)

Foster, A. A.
NURSERY DISEASES OF SOUTHERN PINES. U. S. Dept. Agr. Forest Pest Leaflet 32, 7 pp., illus. (Cause, symptoms, and control for damping-off, black root rot, nematode injury, fusiform rust, brown spot, and chlorosis.)

Froelich, R. C.
DEFECT IN MERCHANTABLE SAWTIMBER IS LARGELY VISIBLE. South. Lumberman 198(2466): 34-35, illus. (The importance of different types of cull in sawtimber as determined by studies in Virginia, North Carolina, and South Carolina.)

Gaby, L. I.
OPERATION PREDRY . . . VARIABLES IN DRYING SOUTHERN PINE. Forest Prod. Jour. 9(5): 23A-26A. (Reports on drying southern yellow pine lumber with forced-air and on the influence of several introduced drying variables.)

Gruschow, G. F.
INCIDENCE OF ROT IN HARDWOOD SAWTIMBER IN COASTAL NORTH CAROLINA. Jour. Forestry 57: 370-371. (Data on the incidence and amount of decay, by species, of the hardwood component of 100-year-old loblolly pine stands in coastal North Carolina.)

Gruschow, G. F.
OBSERVATIONS ON ROOT SYSTEMS OF PLANTED LOBLOLLY PINE. Jour. Forestry 57: 894-896, illus. (Survey of root systems of bar-planted seedlings in southeastern Virginia.)

Gruschow, G. F., and Evans, T. C.
THE RELATION OF CUBIC-FOOT VOLUME GROWTH TO STAND DENSITY IN YOUNG SLASH PINE STANDS. Forest Sci. 5(1): 49-55, illus. (Relationships between growth per acre, stand density, and site quality in flatwoods of northeastern Florida and southeastern Georgia.)

Guilkey, P. C.
THE INFLUENCE OF VEGETATIONAL LAYERS ON COVER MEASUREMENTS. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 101-104. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta. (Most methods and instruments now available can be adapted for use if the various layers can be defined satisfactorily.)

Haney, G. P., and Metz, L. J.
SILVICAL CHARACTERISTICS OF SOUTHERN RED OAK. Southeast. Forest Expt. Sta. Paper 106, 9 pp., illus. (Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Hepting, G. H.
DISEASE LOSSES IN SOUTHERN PINE SEED DURING CONE PRODUCTION. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 36-39. (The most important disease interfering with seed production in a southern pine is the cone rust caused by *Cronartium strobilinum*. Oaks are alternate hosts.)

Hepting, G. H.
FOREST PATHOLOGY IN FOREST MANAGEMENT IN THE UNITED STATES. (Abs.) IX Internatl. Bot. Cong. Proc. 2: 161-162. (Most research is aimed at practical aspects of causes and control. The fundamentals of behavior of trees and pathogens will be given greater emphasis in future research.)

Hepting, G. H.
MEETING THE PROBLEM OF FOREST DISEASES. Forest Farmer 18(8): 46-48. (Describes major forest diseases in the Southeast and progress in combating them.)

Hilmon, J. B.
DETERMINATION OF HERBAGE WEIGHT BY DOUBLE-SAMPLING: WEIGHT ESTIMATE AND ACTUAL WEIGHT. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 20-25, illus. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta. (Double-sampling provides faster and more efficient estimates of forage production and utilization on native forage in a rates of cattle stocking study in south Florida.)

Hodges, C. S.
HISTOLOGICAL STUDIES OF ROOTS OF PINE SEEDLINGS INFECTED WITH BLACK ROOT ROT. (Abs.) Phytopathology 49(5): 318. (*Sclerotium bataticola* and *Fusarium* spp. are associated with the disease and pathogenic in inoculation tests; former produces indolacetic acid, which can cause marked proliferation of root cortex.)

Hughes, R. H.
THE WEIGHT-ESTIMATE METHOD IN HERBAGE PRODUCTION DETERMINATIONS. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 17-19. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta. (Describes procedures and uses of weight-estimate method on range lands of the South and East.)

Johansen, R. W.
MONOAMMONIUM PHOSPHATE SHOWS PROMISE IN FIRE RETARDANT TRIALS. Southeast. Forest Expt. Sta. Res. Note 137.
(Aerially-dropped loads of monoammonium phosphate stopped surface head fires in highly combustible fuels in south Georgia.)

Johansen, R. W., and Kraus, J. F.
FERTILIZING CLEFT AND BOTTLE GRAFT SCIONS IN AN ATTEMPT TO INCREASE GRAFT UNIONS. Jour. Forestry 57: 511, 514.
(Scion-fertilization treatments in the concentrations used did not have a beneficial effect on the success of either cleft or bottle grafts.)

Johansen, R. W., and Turner, J. C.
EFFICIENT USE OF AERIAL TANKERS IN THE SOUTHEAST. South. Lumberman 199(2489): 99-100, illus.
(In open areas, 220-gallon drops of fire retardant material are adequate; in well-stocked stands, 440-gallon drops are required.)

Jones, E. P., Jr.
WET SITE SURVIVAL AND GROWTH. Southeast. Forest Expt. Sta. Res. Note 130.
(Survival and growth of planted yellow-poplar, eastern cottonwood, slash pine, and loblolly pine.)

Keetch, J. J.
UNIFYING FIRE DANGER RATING—PROGRESS TOWARD A NATIONAL SYSTEM. Fire Control Notes 20(3): 87-88.
(A short history of the project to develop a unified national fire danger system and a brief progress report.)

Keetch, J. J., and Gladstone, M. C.
1958 FOREST FIRES AND FIRE DANGER IN MAINE AND RHODE ISLAND.
(Two separate reports containing tables and graphs analyzing forest fires and fire danger.)

Klawitter, R. A.
DIRECT SEEDING HARDWOODS. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 154-158.
(Results of direct seeding cherrybark, Shumard, and swamp chestnut oak at Charleston, S. C.)

Klawitter, R. A.
PRESCRIBED BURNING CAN PAY ITS WAY. Forest Farmer 18(9): 9, 14-15, illus.
(Logging costs in loblolly pine were substantially reduced by controlling a hardwood understory with periodic winter fires.)

Kowal, R. J.
BIOLOGICAL CONTROL OF BALSAM WOOLLY APHID—WILL IT SUCCEED IN THE SOUTH? Forest Farmer 19(2): 6-7, illus.
(Discussion of balsam woolly aphid problem near Mt. Mitchell and description of efforts to control it by biological methods.)

Kowal, R. J.
MEETING THE PROBLEM OF TREE-KILLING INSECTS. Forest Farmer Manual 18(8): 38-46.
(Progress in improving detection and reporting of insect outbreaks and in research on control of important southern forest pests.)

Kowal, R. J.
SHADE TREE INSECTS IN THE SOUTH—THEIR INCREASING IMPORTANCE AND CONTROL. 34th Natl. Shade Tree Conf. Proc. 1958: 159-171.
(Damage caused to shade trees by some of our common forest insects; recommendations for control, primarily cultural in nature.)

Kraus, J. F.
METHOXONE TREATMENT OF LONGLEAF PINE SEED. Jour. Forestry 57: 650.
(High concentrations of methoxone were toxic to longleaf pine seed; low concentrations did not shorten length of time seedlings stayed in the grass.)

Langdon, O. G.
SITE INDEX CURVES FOR SOUTH FLORIDA SLASH PINE. Southeast. Forest Expt. Sta. Res. Note 133.
(Regression of logarithm of total height on reciprocal of age was computed and expressed in terms of site index at age 25 years.)

Langdon, O. G.
SITE PREPARATION REQUIREMENTS FOR DIRECT SEEDING OF LONGLEAF AND SLASH PINES. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 109-113.
(Discusses factors limiting initial stand establishment for direct seeding.)

Larson, R. W.
TIMBER IN NORTH CAROLINA. U. S. Dept. Agr. Forest Resource Rpt. 15, 24 pp., illus.
(Illustrated presentation of current timber supply trends, possible future needs, and problems that must be solved to increase timber supply.)

Larson, R. W.
USE OF TRANSECTS TO MEASURE LOW VEGETATIVE COVER. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 48-54. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Describes uses, advantages, and disadvantages of various types of transects, including belt, strip, or line intercept method.)

Larson, R. W., and Bryan, M. B.
VIRGINIA'S TIMBER. Southeast. Forest Expt. Sta. Forest Survey Release 54. 72 pp., illus.
(Statistics on forest and nonforest areas, timber volume, growth, mortality, and cut, with trends in forest area and timber volume between first and second surveys.)

Lotti, Thomas
SELECTING SOUND ACORNS FOR PLANTING BOTTOMLAND HARDWOOD SITES. Jour. Forestry 57: 923, illus.
(Identification of weeviled acorns of swamp chestnut, Shumard, and cherrybark oaks by visual characteristics.)

Lotti, Thomas
A SPECIAL FIRE PLAN FOR THE SANTEE EXPERIMENTAL FOREST. Southeast. Forest Expt. Sta., 26 pp., illus.
(Analysis of such items as 10-year-fire occurrence and protection priorities; detailed action plan for maximum protection of a high-value area.)

Lotti, Thomas, and LeGrande, W. P.
LOBLOLLY PINE SEED PRODUCTION AND SEEDLING CROPS IN THE LOWER COASTAL PLAIN OF SOUTH CAROLINA. Jour. Forestry 57: 580-581, illus.
(Five-year seed production in two 50-year-old stands and seed and seedling losses. One stand had annual summer prescribed burns.)

Lund, A. E., and Taras, M. A.
KILN DRYING CHEMICALLY TREATED SCARLET OAK AND WHITE OAK LUMBER. Forest Prod. Jour. 9(11): 398-403.
(Indicates chemical treatment with salt can help minimize honeycomb degrade when high temperature and rapid drying schedules are used.)

McAlpine, R. G.
FLOODING KILLS YELLOW-POPLAR. Forest Farmer 19(3): 9, 13-14, illus.
(High mortality of yellow-poplar planting caused by flooding during growing season.)

McAlpine, R. G.
IS THERE A FUTURE IN COTTONWOOD? Forest Farmer 18(12): 12-13, 16, 18.
(Reports on 3-year growth and survival of cottonwood plantings in Georgia Piedmont.)

McAlpine, R. G.
RESPONSE OF PLANTED YELLOW-POPLAR TO DIAMMONIUM PHOSPHATE FERTILIZER. Southeast. Forest Expt. Sta. Res. Note 132.
(First-year height growth increased with increasing rates of application of diammonium phosphate (20-52-0).)

McAlpine, R. G.
YELLOW-POPLAR RESPONDS TO FERTILIZATION. South. Lumberman 199(2489): 95-96, illus.
(Second-year measurements show widening gap between plots fertilized with diammonium phosphate and control plots.)

McAlpine, R. G., and Jackson, L. W. R.
EFFECT OF AGE ON ROOTING OF LOBLOLLY PINE AIR-LAYERS. Jour. Forestry 57: 565-566, illus.
(Rooting was best in the youngest age classes and declined sharply with increasing age. None of the air-layers rooted on trees 17 and 20 years of age.)

McGee, C. E.
WEIGHT OF MERCHANTABLE WOOD WITH BARK FROM PLANTED SLASH PINE IN THE CAROLINA SANDHILLS. Southeast. Forest Expt. Sta. Res. Note 128.
(Tables of green weight of wood with bark for trees by diameter and height classes to a fixed top outside bark of 2.0, 3.0, and 4.0 inches.)

McGee, C. E., and Bennett, F. A.
CUBIC FOOT VOLUME TABLES FOR SLASH PINE PLANTATIONS OF THE MIDDLE COASTAL PLAIN OF GEORGIA AND THE CAROLINA SANDHILLS. Southeast. Forest Expt. Sta. Res. Note 129.
(Cubic foot volumes inside bark and outside bark by diameter and height classes to fixed tops outside bark of 2.0, 3.0, and 4.0 inches.)

McGee, C. E., and Bennett, F. A.
SITE INDEX CURVES FOR OLD-FIELD SLASH PINE PLANTATIONS. Southeast. Forest Expt. Sta. Res. Note 127.
(Regression of logarithm of total height on reciprocal of age was computed and expressed in terms of site index at age 25 years.)

Meginnis, H. G.
INCREASING WATER YIELDS BY CUTTING FOREST VEGETATION. Internatl. Assoc. Sci. Hydrol. Pub. 48: 59-68, illus. (Symposium Hannover-Munden, 8-13 Sept., 1959.)
(Discusses increases in water yield by cutting forest vegetation; need for more basic knowledge of water use requirements of cover and of plant-soil-climatic factors which govern evapotranspiration.)

Merkel, E. P.
INSECTS CAUSING SEED LOSSES IN SEED-PRODUCTION AREAS. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 32-35.
(Describes some of the major flower, cone, and seed insect pests affecting slash and longleaf pines.)

Merkel, E. P., Beers, W. L., and Hoekstra, P. E.
PROBLEMS INVOLVED IN THE CONTROL OF CONE INSECTS BY AERIAL SPRAYING. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 77-81.
(Discusses results of recent aerial spray tests for control of cone insects in South. Recommendations for future aerial spray experiments are considered.)

Metz, L. J.
THE DESCRIPTION AND MEASUREMENT OF THE FOREST FLOOR. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 105-113, illus. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Discusses nomenclature and methods of measurement of components and characteristics of forest floor.)

Metz, L. J., and Douglass, J. E.
SOIL MOISTURE DEPLETION UNDER SEVERAL PIEDMONT COVER TYPES. U. S. Dept. Agr. Tech. Bul. 1207, 23 pp., illus.
(Compares soil moisture regime of pine, pine-hardwood, grass, and bare soil, particularly moisture depletion by depths to 66 inches over a 5-year period.)

Nagel, W. P.
FOREST INSECT CONDITIONS IN THE SOUTHEAST DURING 1958. Southeast. Forest Expt. Sta. Paper 100, 10 pp., illus.
(Discussion of survey and control activities.)

Nelson, R. M.
DROUGHT ESTIMATION IN SOUTHERN FOREST FIRE CONTROL. Southeast. Forest Expt. Sta. Paper 99, 22 pp., illus.
(Suggests tentative method for estimating soil moisture from measurements of mean temperature and precipitation.)

Nelson, T. C.
SILVICAL CHARACTERISTICS OF MOCKERNUT HICKORY. Southeast. Forest Expt. Sta. Paper 105, 10 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Olson, D. F., Jr.
SITE INDEX CURVES FOR UPLAND OAK IN THE SOUTHEAST. Southeast. Forest Expt. Sta. Res. Note 125.
(New site index curves for white, northern red, southern red, scarlet, black, and chestnut oaks in Virginia-Carolina Piedmont and Southern Appalachian Mountains.)

Olson, D. F., Jr., and Della-Bianca, Lino
SITE INDEX COMPARISONS FOR SEVERAL TREE SPECIES IN THE VIRGINIA-CAROLINA PIEDMONT. Southeast. Forest Expt. Sta. Paper 104, 9 pp., illus.
(Charts and equations for estimating site index of shortleaf pine, northern red oak, southern red oak, scarlet oak, black oak, and white oak when site index of yellow-poplar is available.)

Olson, D. F., Jr., and Doyle, H. J.
PIEDMONT FARM WOODLANDS. Furniture, Plywood, and Veneer Council of the North Carolina Forestry Association, Inc., Report 5, 18 pp., illus.
(Income, cost, and net profit from woodland operation on two small woodlots in North Carolina Piedmont.)

Page, R. H.
GEORGIA'S HARDWOODS—PROBLEM OR OPPORTUNITY? Cross Tie Bul. 40(12): 37-39.
(Points out overabundance of low-quality hardwoods in Georgia and part that wood utilization research is playing in providing profitable outlets.)

Page, R. H., and Saucier, J. R.
COMPRESSION WOOD. Forest Utilization Serv. Release 20.
(Practical information for recognizing and avoiding deleterious effects of compression wood in pine lumber.)

Peter, R. K.
NEW UNITIZING METHODS FOR PARQUET FLOORS. Wood & Wood Products 64(4): 48, 56-57.
(Proposes and describes several new methods for unitizing parquet flooring that are adapted to fast production and mechanical handling.)

Ripley, T. H., and Campbell, R. A.
THE WHITE-TAILED DEER—A BLESSING AND A PROBLEM. Wildlife in North Carolina 23(9): 14-15.
(Discusses opportunities and problems of managing hardwoods in Southern Appalachians for both timber and game.)

Robinson, V. L.
PULPWOOD PRICE TRENDS IN THE SOUTHEAST. Southeast. Forest Expt. Sta. Res. Note 136. Also in Paper Trade Jour. 143(52): 22.
(Average prices paid in Southeast for pine pulpwood from 1945-1958; separate prices listed for rail wood, yard wood, truck wood, and weighted average for all types of delivery.)

Roth, E. R.
HEART ROTS OF APPALACHIAN HARDWOODS. U. S. Dept. Agr. Forest Pest Leaflet 38, 4 pp., illus.
(Describes important fungi causing basal, top, and trunk decay; methods given for reducing decay losses.)

Roth, E. R., Hepting, G. H., and Toole, E. R.
SAPSTREAK DISEASE OF SUGAR MAPLE AND YELLOW-POPLAR IN NORTH CAROLINA. Southeast. Forest Expt. Sta. Res. Note 134.
(The disease has not spread out of its original restricted range. Inoculations with causal fungus have killed both host species; natural spread and killing are slow.)

Saucier, J. R., and Page, R. H.
A DIRECTORY OF WOOD-USING INDUSTRIES IN GEORGIA. Georgia Forestry Comn. and Southeast. Forest Expt. Sta., Ed. 2, 109 pp.
(Classifies Georgia's wood-using industries by location, type of operation, materials purchased, and products sold.)

Shipman, R. D.
SILVICAL CHARACTERISTICS OF WINGED ELM. Southeast. Forest Expt. Sta. Paper 103, 7 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Sluder, E. R.
GROWTH AND THE EFFECT OF PRUNING IN A STAND OF SYCAMORE IN THE SOUTHERN APPALACHIANS. South. Lumberman 199(2489): 145-146, illus.
(Pruning a natural stand of sycamore will result in maximum production of high-quality wood.)

Speers, C. F.
A PORTABLE FIELD CAGE FOR INSECTS. Coop. Econ. Insect Rpt. 9(16): 297-299, illus.
(Plans for cage for use in laboratory or easily transported and quickly erected over a plant or around the stem of a tree to almost any height.)

Squillace, A. E., and Kraus, J. F.
EARLY RESULTS OF A SEED SOURCE STUDY OF SLASH PINE IN GEORGIA AND FLORIDA. Fifth South. Conf. on Forest Tree Improvement Proc. 1959: 21-34.
(Seed collected from an apparently optimum climatic zone seems to be moderately superior even when planted in other climates within the range of the species.)

Storey, T. G., Wendel, G. W., and Altobellis, A. T.
TESTING THE TBM AERIAL TANKER IN THE SOUTHEAST. Southeast. Forest Expt. Sta. Paper 101, 25 pp., illus.
(Pattern sizes and rates of slurry application for half load and full load TBM drops in a variety of fuel types in Georgia and North Carolina.)

Taras, M. A., and Hudson, Monie
SEASONING AND PRESERVATIVE TREATMENT OF HICKORY CROSSTIES. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 8, 24 pp., illus.
(Compilation of six years work on seasoning and treatability of hickory crossties by various railroads, schools, treating companies, and public agencies.)

Trousdell, K. B.
SITE TREATMENT REDUCES NEED FOR PLANTING AT LOBLOLLY HARVEST TIME. Southeast. Forest Expt. Sta. Paper 102, 11 pp., illus.
(Loblolly pine regenerates naturally provided seed trees are adequate, harvest takes place in moderately good seed year, soil is scarified, and hardwoods are controlled.)

Vimmerstedt, J. P.
SITE INDEX CURVES FOR SOUTHERN APPALACHIAN WHITE PINE PLANTATIONS. Southeast. Forest Expt. Sta. Res. Note 131.
(Regression of logarithm of total height on reciprocal of age was computed and expressed in terms of site index at age 25 years.)

Walker, L. C., and Brender, E. V.
PLANTING FOLLOWING PRESCRIBED FIRE. Jour. Forestry 57: 123-124.
(Planting immediately after a winter burn can be an effective way to convert brush to good pine stocking.)

Whisnant, H. H., and Olson, D. F., Jr.
A PLANTING BAR EXTENSION FOR SETTING LARGE-ROOTED SEEDLINGS. Tree Planters' Notes 36: 6-7, illus.
(How to make and use a sheet metal extension on a standard planting bar when larger holes are needed in hand planting.)

Zak, Bratislav
LITTLELEAF DISEASE OF SHORTLEAF PINE (PINUS ECHINATA MILL.). (Abs.) IX Internatl. Bot. Cong. Proc. 2: 440-441.
(Littleleaf is usually associated with poorly drained soils. It results from a combination of root killing by the soil fungus *Phytophthora cinnamomi*, poor soil aeration, and low soil fertility.)